Construction Documents
Specifications

Cornell University

BALCH HALL RENOVATION

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Volume 2 of 2 **Division 23** through **33**

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Section 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. Where conflicts occur between divisions, the more stringent requirement shall apply.

B. Related Sections:
1. All sections within Division 23 – Heating, Ventilating, and Air Conditioning.
2. All sections within Division 25 – Controls.
3. All sections within Division 01 – General Requirements.
4. Relevant sections within Division 03 – Concrete.
    a. Section 03 10 00 – Concrete Forming and Accessories.
    b. Section 03 30 00 – Cast-In-Place Concrete.
    c. Section 03 37 13 – Shotcrete.
    d. Section 03 38 00 – Post-Tensioned Concrete.
5. Relevant sections within Division 05 – Metals.
    a. Section 05 12 00 – Structural Steel Framing.
    b. Section 05 31 00 – Steel Decking.
    c. Section 05 50 13 – Metal Service Platforms.
6. Relevant sections within Division 07 - Thermal and Moisture Protection.
    a. Section 07 21 00 – Thermal Insulation.
    b. Section 07 62 00 – Sheet Metal.
    c. Section 07 84 00 – Fire Stopping.
    d. Section 07 86 00 – Smoke Seals.
7. Relevant sections within Division 08 – Openings.
    a. Section 08 10 00 – Doors and Frames.
    b. Section 08 31 13 – Access Doors and Frames.
    c. Section 08 71 00 – Door Hardware.
    d. Section 08 90 00 – Louvers and Vents.
8. Relevant Sections within Division 09.
    a. Section 09 90 00 – Painting and Coating.
    b. Section 09 29 00 – Gypsum Board.
9. Relevant sections within Division 11 – Equipment.
    a. Section 11 40 00 – Food Service Equipment.
    b. Section 11 53 00 – Laboratory Equipment.
10. Relevant sections within Division 21 – Fire Protection Systems.
    a. Section 21 12 00 – Fire Suppression Standpipe Systems.
    b. Section 21 13 00 – Fire Suppression Sprinkler Systems.
    c. Section 22 22 00 – Gaseous Agent Suppression Systems.
    d. Section 22 30 00 – Fire Pumps.
11. Relevant sections within Division 22 – Plumbing.
    a. Section 22 10 00 – Plumbing Pumps.
    b. Section 22 30 00 – Plumbing Equipment.

c. Section 22 60 00 – Mechanical Gas Systems.
d. Section 22 05 03 – Pipes and Tubes for Plumbing Piping and Equipment.

12. Relevant sections within Division 26 – Electrical.
    a. Section 26 05 03 – Equipment Wiring Connections.
    b. Section 26 05 26 – Grounding and Bonding for Electrical Systems.
    c. Section 26 24 19 – Motor Control Centers.
    d. Section 26 05 19 – Low Voltage Electrical Power Conductors and Cables.
    e. Section 26 22 00 – Low Voltage Transformers.
13. Relevant sections within Division 28 - Electronic Safety and Security.
    a. Section 28 31 00 – Fire Detection and Alarm.

1.2 SUMMARY

A. The requirements of this section apply to all the Work of Division 23.

B. This Section Includes the following:
1. Applicable codes.
2. General project requirements.
3. Concrete pads.
4. Rooftop equipment support.
5. Roof openings and curbs.
6. Grout.
7. Access panels.
8. General installation requirements.
9. General testing requirements.

1.3 REFERENCES

References to standard codes, specification of regulatory agencies shall mean editions in effect at date of proposal. Reference to technical societies, trade organizations, and governmental agencies is made in this Division in accordance with the following abbreviations:

1. AABC Associated Air Balance Council
2. ADCD Air Diffusion Council - Test Code
3. AGA American Gas Standard
4. AMCA Air Moving and Conditioning Association
5. ANSI American National Standards Institute
5. ARI Air Conditioning and Refrigeration Institute
6. ASA American Standards Association
7. ASC Adhesive and Sealant Council
8. ASHRAE American Society of Heating, Refrigerating, and Air Conditioning Engineers
9. ASME American Society of Mechanical Engineers
10. ASSE American Society of Sanitary Engineering
11. ASTM American Society for Testing and Materials
12. AWS American Welding Society
13. AWWA American Water Works Association
14. CISPI Cast Iron Soil Pipe Institute
15. CMR Code of Massachusetts Regulations
16. CS Commercial Standards - US Dept.

17. EPA Environmental Protection Agency
18. FMS Factory Mutual System General Industry Safety Orders, Article 3281
19. HEW US Dept. of Health, Education and Welfare
20. HI Hydraulic Institute
21. IAPMO International Association of Plumbing and Mechanical Officials
22. IBC International Building Code
23. IECC International Energy Conservation Code
24. IFC International Fire Code
25. IMC International Mechanical Code
26. IMSS Manufacturers' Standardization Society
27. IPC International Plumbing Code
28. IRI Industrial Risk Insurers
29. LEED® Leadership in Energy and Environmental Design
30. NBS National Bureau of Standards
31. NCWB National Certified Piping Welding Bureau
32. NEBB National Environmental Balance Bureau
33. NEC National Electrical Code
34. NEMA National Electrical Manufacturers' Association
35. NFPA National Fire Protection Association
36. OSHA Occupational Safety and Health Administration
37. PDI Plumbing and Drainage Institute
38. SMACNA Sheet Metal and Air Conditioning Contractors National Association
39. UL Underwriters Laboratories, Inc.
40. USGBC United States Green Building Council

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. "Regulating Authorities" means all governmental, utility and fire protection authorities having jurisdiction.

G. "Provide" means to supply, erect, install and connect up completely, in readiness for regular operation, the particular work referred to.

H. "Furnish" means purchase, store and deliver the specified material, equipment or other item to the person or party indicated.

I. "Approved Equal" means any equipment or material which in the opinion of the architect, is equal in quality, durability, appearance, strength, design and performance to the equipment or material specified and will function adequately in accordance with the general design.

J. "Singular Number": Where any device is herein referred to in the singular number, such reference shall be deemed to apply as many such devices as are required to complete the installation or as many as are shown.

K. "Piping" as used in the drawings and specifications means all pipe, fittings, nipples, flanges, valves, unions, hangers and supports that are required for a complete functional system.

L. "Ductwork" as used in the drawings and specifications means all ductwork, fittings, dampers, air terminal devices, diffusers, registers, grilles, hangers and supports that are required for a complete functional system.

M. "Wiring" includes, in addition to conductors, all raceways, conduit, fittings, boxes, switches, hangers and other accessories related to such wiring.

N. "Contract Documents" or "Documents" shall mean the latest version of all drawings and specifications prepared by the Engineer and Architect.

O. "Authority Having Jurisdiction" or "AHJ" shall mean the building department, fire department, inspectorate or other authority having legal jurisdiction relevant to the specific work being described in the City or State where the project is located.

P. The following are industry abbreviations for plastic materials:
1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

Q. The following are industry abbreviations for rubber materials:
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.5 REGULATIONS, CODES, PERMITS AND FEES

A. Before bidding, be familiar with rulings of inspection departments and comply with such requirement. Codes, standards and specifications applicable to this work shall be the latest editions in effect at the date of the proposal.

B. It is not the intent of Drawings and Specifications to repeat requirements of codes except where necessary for completeness or clarity.

C. All work and material shall be in full accordance with the latest rules and regulations of the following agencies:

1. Safety Orders of the Division of Industrial Industry

2. International Building Code
3. International Mechanical Code
4. Uniform Plumbing Code
5. Uniform Mechanical Code
6. National Electric Code
7. National Fire Protection Association Pamphlets 13, 14, 24 and 291
8. Listing and approval of Underwriters' Laboratories, Inc. where available and applicable.
9. Listing and approval of American Gas Association where available and applicable.

D. Rulings and interpretations of authorities shall be considered a part of the regulations.

E. Where the standards of the drawings and specifications for materials and/or workmanship are higher than the requirements of the documents cited above, the drawings and specifications shall take precedence; otherwise the documents shall govern.

F. Nothing in these plans or specifications is to be construed to permit work not conforming to these codes and regulations.

G. Should there be any direct conflict between the above rules and the specifications, the rules shall govern.

H. Charges for all materials and labor required for compliance with these rules and regulations shall be included in the Bid Price.

I. Give necessary notices, obtain permits and pay taxes, fees and other costs in connection with work; file necessary plans, prepare documents and obtain necessary approvals of regulating authorities having jurisdiction; obtain all required Certificates of Inspection for Work and deliver to Architect before request for acceptance and final payment for Work.

J. Include in Work, without extra cost to Owner, labor, materials, services, apparatus, drawings (in addition to Contract Drawings and Documents) required to comply with applicable laws, ordinances, rules and regulations.

K. Conform to all rules, regulations, laws, and ordinances governing the area in which this construction occurs.

L. Obtain the required permits from the local authorities for this work and pay for all fees required by the State and Federal authorities for permits, inspections and review, including special agency construction and operating permits. Make corrections in the work as required by the Owner's Representative or Inspector to pass local regulations.

M. Provide local authorities with all notices relating to this Division.

N. Provide Owner, Owner's Representative and local Inspectors access to work at all times.

O. Contractor shall be responsible for all law violations caused by the work under this Division. Notify the Owner's Representative in writing when a discrepancy occurs

between code requirements and work shown on drawings and resolve matter before proceeding with work.

P. Make application and pay for all certificates of inspection, taxes and permits required by Local, State or Federal Governments, public utilities, or other authorities having lawful jurisdiction. Deliver to the Owner's Representative any and all certificates of inspections, permits, and approvals that may be required by such authorities.

Q. All controlled inspections shall be the responsibility of the Contractor. The Contractor shall coordinate all inspections and provide all support and personnel necessary for successful completion.

R. Permits and Fees
1. Make application and pay for all certificates of inspection, taxes and permits required by AHJs. Deliver to the Owner any and all certificates of inspections, permits, and approvals which may be required by AHJs.
2. Pay all utility charges and charges for providing temporary and permanent water, sewer, and gas services to buildings.

1.6 GENERAL REQUIREMENTS

A. Provide a complete mechanical system in full working order without objectionable noise or vibration. The documents do not undertake to show or list every item to be provided. The Contractor shall examine the Documents at the time of the bid and notify the Architect/Engineer in writing of any and all discrepancies. When an item not shown or listed is necessary for the proper operation of equipment which is shown or listed, provide an item which will allow the system to function properly at no increase in Contract Sum. Should there be any direct conflict in the specifications and drawings, an RFI shall be submitted with the Contractor's suggestion for resolution.
1. Provide and install connection to district steam and chilled water system in compliance with District utility requirements and the drawings.
2. Provide and install complete direct digital control system, including devices, controllers, and sensors.
3. Provide testing, adjusting and balancing for all systems. Refer to Section 23 05 93.
4. Provide commissioning services to carry out the collection of data for Pre-Functional and Functional tests per the commissioning requirements specified in Section 23 08 00, Section 01 91 13 and other sections referenced in 01 91 13.
5. Provide, design, dimension, coordinate, and install the following items specified as design build under specified performance criteria:
    a. Support and anchorage of all equipment, valving, piping, duct work, duct silencers and controls equipment and conduit. Refer to Section 23 05 29.
    b. Thermal and seismic expansion. Refer to Section 23 05 16.
    c. Vibration isolation and seismic anchorage. Refer to Section 23 05 48.
    d. Controls programming, architecture, and conduit sizing and routing. Refer to Section 25 55 00 and 25 55 10.
6. Provide all control devices for mechanical equipment and systems in conjunction with control system requirements, including coordination with Division 26 for electrical connection for complete, tested and operational systems.

B. Construction Documents Drawings and Data

1. The drawings show the general arrangement of all piping, ductwork, conduit and equipment. Examine drawings and specifications carefully, and notify the Owner's Representative by letter or Request for Information (RFI) of any discrepancies so these can be rectified at an early date.
2. Should conditions necessitate any rearrangements, the Contractor shall prepare and submit drawings showing the changes before proceeding with the work. If such changes are approved, they shall become a part of this contract after their approval.
3. Due to the small scale of the drawings, it is not possible to show all offsets and every detail of construction. Additional fittings, valves, traps, transitions, ducts, etc., shall be furnished and installed at no extra cost to the Owner. It is not the intent of Drawings and Specifications to repeat requirements of codes except where necessary for completeness or clarity.
4. The drawings are diagrammatic and are a graphic representation of the Contract Requirements, and are intended to convey scope of work. Dimensions of work as indicated on plans are not guaranteed to be as-built dimensions. No measurements shall be scaled from the Drawings for use as a definite dimension for layout or fitting work in place. Location of all items not definitely fixed by dimensions are approximate only. The Contractor is solely responsible for dimensional control and coordination of the work to be installed.
5. The layout of equipment, as shown on the plans, shall be checked and exact location determined by dimensions of equipment accepted for installation. Consult the Architectural and Structural Drawings for all dimensions, locations of partitions, sizes of structural members, foundations, etc. Exact locations necessary to secure best conditions shall be determined in field coordination and shall be approved by the Owner’s Representative prior to installation. In addition, the Owner’s Representative reserves right at no increase in contract sum to make any reasonable change in location of mechanical items exposed at ceilings or on walls to group them in an orderly relationship or increase utility and access.
6. The Contractor shall be responsible for the coordination of the mechanical ducting and piping distribution with the fire sprinklers, lighting, conduit, cable tray, structural members, ceiling support and all other trades present within the project.
7. At the Owner’s direction, electronic files of the documents may be available to the Contractors subject to the following caveats:
    a. Provision of electronic files does not release the contractor from the requirements of the Contract Documents regarding coordination, submittals or any other issues outlined in the Contract Documents.
    b. The official Contract Documents are the hard copy versions, not the electronic files.
    c. The Contractor is responsible for all information extracted or inferred from the electronic files.
    d. Submission of the electronic file unchanged as a shop drawing will be rejected without review.
    e. These documents are provided only as a convenience to the Contractor. The Architect/Engineer is under no obligation to provide updated drawings during the Construction Phase or to track changes arising from RFIs, change orders, substitution requests, or submittal-generated alterations.

8. Where three-dimensional CAD files are provided as a portion of the construction documents, these files are used to represent the designer’s intent to show a viable solution with regard to the elevations, sizes, and routing of the mechanical system around the structural obstacles and other trades known at the time of

design. Although the piping, conduit, control panels, support, or construction of other trades maybe shown for reference in certain locations in order to generate 2D sections, the placement of these items in the 3D model are as an allowance for reference only, and they are located on an as-needed basis for the purposes of demonstrating a solution for coordination in an area known to be particularly congested. The presence of this information does not imply that complete coordination has occurred, as there are many trades that are design-build with regard to placement. The presence of this information does not absolve the contractor of responsibility for field coordination with all trades. The lack of multi-trade information in other portions of the model does not imply that these areas are conflict-free.

9. Where 3D CAD files are provided, the following trades are known to be design-build and are thus incompletely represented if present at all: fire protection/ sprinkler routing, all electrical conduit locations, all controls conduit, all trades' support and seismic bracing details, all trades' vibration isolation, all trades' access area limitations, ceilings and their supports.
10. Three-dimensional CAD files are to be used as guides in the same way as the 2D drawings mentioned above, in that dimensions are not guaranteed. The dimensional distance from a column line or the dimensional elevation within the 3D drawings are not to be interpreted as fixed engineering design direction, but rather as the representation of intent, given the available information during the CD design phase. As other trades' design input show a conflict, it will be necessary for the mechanical subcontractor to perform the work of field coordination, at no cost, as required by Division 1.
11. Where 3D files are provided and a discrepancy is noted, it is the mechanical construction documents' organizational intent to show information in the following primary locations in order of preference:

Information Location Precedence Chart.
(1st means primary precedence. A blank means that no geometrical information from that source may be used.)

Item	**3D files**	**2D plan or section drawings**	**Detail Drawings/ single line diagrams**	**Specifications**
Elevation	1st	2nd		
Horizontal location	1st	2nd		
Duct Size	1st	2nd		
Pipe Size	3rd	2nd		1st for size limitations only
Equipment physical size	2nd	3rd	1st	
Descriptive annotations		1st	2nd	
Repeated details such as equipment connection details			2nd	1st
Insulation thickness				1st
Pipe, duct, and equipment support /vibration isolation devices and locations			2nd	1st: performance specification

Item	3D files	2D plan or section drawings	Detail Drawings/ single line diagrams	Specifications
Piping expansion compensation devices and locations		3rd	2nd	1st: performance specification
Control panel locations				1st: performance specification
Pad location		1st		
Visible control sensor locations		1st, in conjunction with architect		
Diffuser locations		1st in conjunction with architect		

12. Any conflicts between 3D files, 2D files, sections, detail drawings, single line drawings, and specifications are to be resolved by a Request for Information (RFI).

C. Minor Deviation from Construction Documents
1. The equipment listed by model number and manufacturer in the plans and specifications has been selected for its capacity, certain standard construction features and specified optional features.
2. The dimensions and ratings of equipment herein specified or indicated on the Drawings are intended to establish the desired performance characteristics of such equipment. Minor deviations may be permitted after review by the Owner's Representative to allow manufacturers specified to bid on their nearest standard equipment that provides at least the performance required.
3. Manufacturers' catalog or model numbers and types mentioned in the Specifications or indicated on the drawings are intended to be used as guides and shall not be interpreted as taking precedence over specific ratings or duty called for or shown, which modify stipulations in such catalogs. In all cases, the manufacturer shall verify the duty specified with the particular characteristics of the equipment he intends to submit, and shall submit only items which comply with Specification requirements.
4. Where the equipment furnished differs in physical character from that specified or indicated, or where Contractor's substituted equipment requires increased service and facilities to be provided by other trades, and such substitution is acceptable to the Owner's Representative, the Contractor shall bear all costs of providing services, facilities and modifications to the system or building.
5. Where the equipment furnished requires redesign of systems, connections, or configuration, and such substitution is acceptable to the Owner's Representative, the contractor shall bear all costs associated with design engineering and shall pay the time and materials cost of the Owner's Representative's review of this documentation. In addition, it is the contractor's responsibility to obtain approval from the authority.

6. For routing of air, water, or steam distribution and conduits, the contractor is empowered to suggest an optimized routing or resizing, given that the routing has been entirely field coordinated, it adds no pressure drop, it does not disturb the functional intent, there is no charge to the client, and all changes are explicitly annotated through symbols in the shop drawings as having deviated from the construction documents proposed routing solution.
7. The shifting of any item horizontally by less than 10', the change of any elevation by less than 3', the resizing of ductwork for equivalent frictional loss, and the necessary fittings in order to accomplish this shall all be construed as accommodation for field coordination and cannot be back-charged as change orders to the client.

1.7 SUBMITTALS PROCEDURES

A. Section 01 33 00 - Submittal Procedures: Submittal Procedures apply to this section. Where conflicts occur between divisions, the more stringent requirement shall apply.

B. Preliminary Submittals
1. Preliminary List of Materials, Equipment and Subcontractors
a. Submit a Preliminary List of Materials, Equipment and Subcontractors to the Owner's Representative for approval of manufacturers of all materials and equipment proposed to be provided for this project, and contact information for all proposed Subcontractors. List shall be configured as follows:

Specification/ Section number	Clause Number	Equipment Type	Proposed Manufacturer/ Contractor Name	Proposed Manufacturer Model Series/ Contractor contact information	Is this Manufacturer/contractor named in the drawings?	s this Manufacturer/ contractor named in the Specifications ?	(For Owner's Representative)	
							Is this a Substitution?	Rejected?

b. List will be returned to the contractor with marks in the far right column with regards to whether the particular manufacturer is rejected due to poor past performance or known incompatibilities with the requirements. Lack of comment in these columns does not imply that the final

manufacturer/model proposed will be acceptable. In all cases, the contractor bears the responsibilities to prove that the proposed product meets the specification and the performance required in the documents.

c. The review of the Preliminary List of Material, Equipment and subcontractors shall only be construed to be a general review that the manufacturer or subcontractor is a recognized and reputable supplier of that general type of product or service and therefore eligible to submit in detail for review. The review designation of "no exception taken" to the Preliminary List does not exempt the Contractor from proving that the particular and specific equipment or Subcontractor meets the project's requirements during the Submittal phase.

d. Submit the List of Materials, Equipment and Subcontractors for review in accordance with Section 01 33 00: Submittal Procedures. Submit at least two months prior to the first submittal.

2. Submittal Schedule
   a. Provide a submittal schedule at least two months prior to the first detailed submittal.
   b. The submittal schedule shall be a complete list of all submittals to be made with submittal number, projected date of submittal, description of submittal by Specification or drawing number and whether a substitution is proposed.
   c. The submittal schedule shall include worst-case submittal status, resolution date and the critical path's target installation date, assuming at least one "Revise and Resubmit" cycle, and shall include the turnaround time period per Division 1. Complicated submittals, such as controls and motorized machinery, shall incorporate time for at least 2 "Revise and Resubmit" cycles. Delay to schedule associated with submittals' "Revise and Resubmit" designation are ineligible for change orders or extensions of time, as timely and correct work is a requirement of this contract.
   d. Concurrent submissions of multiple submittals shall incur a minimum of two times the turnaround time listed in Division 1, or longer, as agreed between reviewing party and the Owner's Representative, based upon the amount and detail level of the documents requiring review. The following items shall be submitted for concurrent reviews:
      1) All controls submissions shall arrive concurrently to allow cross-referencing.
      2) All air handling equipment and duct silencers shall arrive concurrently.
      3) All hydronic central plant equipment shall arrive concurrently.
      4) All VFD submittals (including those embedded in equipment submittals as integral devices) shall be included in VFD harmonic mitigation calculation submittal for reference.
   e. The contractor shall be responsible for equipment ordered and/or installed prior to receipt of submittals returned bearing the Architect/Engineers stamp of "No Exception Taken". Corrections or modifications to equipment as noted on returned submittals shall be at the Contractor's sole expense without additional compensation.
3. Shop Drawing Schedule
   a. Provide a shop drawing submittal schedule that includes fixed dates of inter-trade coordination sign-off prior to submission, including TAB and controls Contractors.
   b. The schedule shall be a complete list by drawing number of all shop drawings to be made, along with projected date of submission, worst-case

shop drawing status resolution date, and critical path's target installation date.

c. The submittal schedule shall assume at least one "Revise and Resubmit" cycle, and shall include the turnaround time period per Division 1. Delay to schedule associated with submittals' "Revise and Resubmit" designation are ineligible for change orders or extensions of time, as timely and correct work is a requirement of this contract.

C. General Organization of Submittals

1. Submit as a minimum all the required data listed in the documents as specifying performance, material, and dimensions. Refer to individual specification sections, schedules, and drawings for requirements.
2. Organize submittals in the same sequence as they appear in specification sections, articles or paragraphs. Label each page with the appropriate specification clause number or drawing detail number.
3. Each submission shall be made under the Specification Section Number it has been specified under. Submittals including equipment specified under a different specification section will be rejected and returned without review. Each section is required to be tracked separately for status designation, even if multiple sections are physically collated into a single binder.
4. Identify each item within each submittal by reference to Specification Section paragraph in which the item is specified, or Drawing and Detail number. Annotate the submittal sheets with the equipment identification numbers appearing on the equipment schedule.
5. Include all information requested by the Specification Section in a single submittal. With the exception of shop drawings, incomplete submittals or phased submittals under the same specification section are not acceptable and will be returned without review, with the Contractor responsible for any resultant consequence.
6. Submit pertinent catalog and performance data sheets only. Annotate pages to clearly identify which specific product is submitted and for what tag number or application. Contractors shall not submit entire catalogs, extraneous information or optional choices. Contractor shall cross out any irrelevant information that may exist on the page, including unadopted options or alternative model types.
7. Submission shall be made in the form of a tab-indexed 3-ring brochure or binder of 8½" x 11" pages or 11" x 17" pre-folded to fit. Index sheets shall be required for all material and equipment, including pipe, valves, insulation, conduit and wire as listed. Index sheets shall be set up, in the same sequence as the specifications, with columns to identify the following:
   a. Specification clause number or drawing/detail number
   b. Item type
   c. Tag number as appropriate and/or application
   d. Requirement from drawing schedule and specification (multiple rows may be used)
   e. Equipment or manufacturer substitution request: yes or no
   f. Feature data provided to show compliance: yes or no
   g. Compliance: yes or no
   h. Notes from Contractor
8. Provide the number of submittal and shop drawing copies as defined under Section 01 33 00.
9. Illegible submittals will be rejected and returned without review.
10. Provide a specification compliance document with every submittal. This can be a marked up relevant specification section noting compliance or exception.

D. Protect existing active services (water, gas, sewer, electric) when encountered, against damage from construction work. Do not prevent or disturb operation of active services which are to remain.

E. Equipment Submittals:

1. Identify each item by manufacturer, brand, trade name, number, size, rating, or whatever other data is necessary to properly identify and check materials and equipment. At a minimum, this should include all information scheduled. Words "as specified" are not sufficient identification.
2. Mark the exact equipment item and data on each sheet. Where multiple product model types are listed on a single sheet, the contractor shall clearly indicate which specific item is submitted. If different model numbers of a single product line are submitted for different uses, this should be clearly annotated, identifying each individual use cross-referenced by the requirement it intends to fulfill. Submittals without annotation will be rejected and returned without review.
3. Submittal literature, drawings and wiring diagrams shall be specifically applicable to this project and shall not contain extraneous material or optional choices. Clearly mark literature to indicate the proposed item and its relevant features or options. Submittals shall include all those items listed in each individual Section.
4. Where a certificate from a regulatory agency cannot be provided at time of submission, provide a letter describing methodology used to obtain certification, authority having jurisdiction, and anticipated date of certification.
5. All built-up equipment (such as air handlers or pump packages) shall be provided with a fully dimensioned shop drawing showing all hardware, points of connection, point loads at supports and center of gravity.
6. Submittals for all factory-built equipment weighing 40 lbs or more shall include a dimensional drawing, equipment weight, and center of gravity.
7. Equipment certification in compliance with IBC seismic requirements shall be included in the original submittal, unless deferred approval is required. If this is the case, a letter shall be provided to state this and a separate submittal number shall be opened to track it.
8. Provide the name and contact information for the three closest manufacturer representatives/service companies for the product.
9. Manufacturer’s certificate of performance and construction.
10. All equipment shall be UL listed as a complete assembly. Submit UL listing documentation with equipment submittals.

F. Shop Drawings:
1. Prepare reproducible CAD drawings in AutoCAD.
2. Shop drawings shall be provided for all systems included in Division 23 and for all areas addressed in the Construction Documents.
3. Ductwork and piping installation drawings shall be fully dimensioned complete with elevations and all fittings, valves, dampers, devices. Include details and dimensioned locations of supports, anchors and expansion devices. Dimensions shall be from gridlines. All equipment shall be shown to scale and shall match the required dimensions from the equipment submittals. All equipment access clearances shall be marked explicitly on the Shop Drawings with manufacturer and code required distances dimensioned and annotated as such.
4. The drawings shall be minimum 1/4" = 1'-0" scale, with Equipment rooms at ½ “=1’-0”.
5. Ductwork and Piping shall be on separate drawings.

a. Ductwork drawings shall include and show equipment with tags, access space, duct construction/material and reinforcing, pressure classification information, flexible duct, flexible connectors, duct support and seismic restraints (internal and external), Balancing devices, gauges/thermometers, controls, devices, penetration locations (including dimensions and elevation), insulation type and location.
b. Piping drawings shall include and show equipment with tags, access space, pipe material, flexible pipe connectors, pipe support type and seismic restraints, balancing devices, gauges/thermometers/Pete's plugs, controls devices, penetration locations (including dimensions and elevation), insulation type and location.

6. Penetration locations, structural support and structural pad drawings shall be submitted for review by Structural Engineer.
7. All equipment shall be labeled to match the schedules. All equipment shall be drawn to scale per the approved submittals, providing notes to identify approved submittal number for all pieces of equipment.
8. The Contractor shall ensure that each trade has coordinated work with other trades, prior to submittal. Division 23 shop drawings shall be issued after the coordination drawings are signed off by all other trades and after the system pressure loss calculations are complete. Any conflicts that occur with other trades shall be brought to the attention of the Owner's Representative prior to issuance of the shop drawings.
9. Shop fabrication, coordination and installation drawings that are prepared to scale by the Contractor are for his use and shall be his responsibility. These Drawings indicate where he intends to install the material and equipment as required by the Contract Documents. Submission of contract documents or electronic files of contract documents for shop drawings is not sufficient as this would be an indication that field-level construction coordination has not taken place. Any such submittal will be rejected and returned without review.
10. Prepare and submit supplementary Shop Drawings for all Work in "tight" areas, clearly indicating solutions to space problems and coordination with Work in other Sections. Identify congested conditions and provide a sufficient number of sections to demonstrate the solution proposed. These Drawings, as a requirement of this Division, shall indicate, superimposed, Work of all Sections involved in congested area, including ductwork, piping, electrical work, ceiling work, equipment access requirements, etc. Include all mechanical rooms at larger scale and with sections under this clause. Identification of space problems without solutions is not acceptable within a shop drawing.
11. During the shop drawing review process the Owner's Representative may request that supplementary shop drawings be produced for clarification and explicit demonstration of coordination in congested areas. This work shall be performed by the contractor at no cost as necessary under the previous clause.
12. Prepare and submit Shop Drawings for all Work deviating from that indicated on Contract Drawings. Clearly indicate deviations and cross reference through notes the reason why the deviation was made.
13. Shop Drawings shall show physical arrangement, construction details, finishes, materials used in fabrications, provisions for piping entrance, access requirements for installation and maintenance, physical size, mechanical characteristics, foundation and support details, weight.
    a. Specifically indicate, by drawn detail or note, that equipment complies with each specifically stated requirement of the Contract Documents.
    b. Drawings shall be to scale and dimensioned (except piping diagrams not to scale).

c. Drawings shall clearly show all required openings in construction, points of connection of other trades, and support locations and loads.
d. Drawings may be prepared by vendor but shall be submitted as instruments of the Contractor. Such drawings shall be thoroughly checked and developed by the contractor to include the full contract scope. They shall be stamped by Contractor before submission for review.
e. Catalog cuts and published material may be included to supplement scale drawings.

14. Each drawing shall have a blank space for use by the Owner's Representative and Contractor in recording disposition of material per Section 01 33 00.

G. Coordinated Drawings:

1. Refer to Section 01 33 00 Submittal Procedures for requirements.
2. Color Coordinated drawings (with different color per trade) shall be provided for all areas with acceptance sign off from all trades required at time of shop drawing submittals, including, but not limited to:
   a. Plumbing Contractor
   b. Electrical Contractor
   c. IT Contractor
   d. AV Contractor
   e. Ceiling Support Contractor
   f. General Contractor
   g. Testing Adjusting and Balancing Contractor
   h. Controls Contractor
   i. Fire Sprinkler Contractor
   j. Fire Alarm Contractor

3. Coordinated Drawings shall show work of all trades including, but not limited to:
   a. Ductwork with fully-dimensioned sized and locations of penetrations at floors, walls, ceiling and roof.
   b. Piping, including:
      1) HVAC, Plumbing and Fire Protection.
      2) Minor Piping such as Drains, Air Vents, Condensate Piping, etc.
      3) Sleeves and fully-dimensioned sized and locations of Penetrations.
      4) Expansion Devices, Anchors, Guides and Hangers, Seismic Anchorage Devices.
   c. Actual Mechanical Equipment at submitted dimensions, including points of connection and manufacturer’s recommended access space. Nothing shall enter or cross through the code-required and manufacturer recommended access space, which is defined as the volume extending from the top of the device to be maintained down to the floor (inclusive of access door locations and swings). Any ceiling which interrupts this space shall be entirely removable including T-bars, vertical supports and seismic bracing of ceiling which shall be arranged to avoid the access zone.
   d. Pipe Supports and Suspension Devices, including seismic restraints.
   e. Ductwork
   f. Piping High Points and Low Points.
   g. Electrical Equipment.
   h. Main Electrical Conduits and Bus Ducts.
   i. Equipment Support and Suspension Devices including Hangers, Supports and Bracing.

j. Structural and Architectural Constraints including Beams, Braces, Trusses, Flanges, Constraints, Walls, Openings Ratings, Doors, Wall Types and Glazing.
k. Show location of:
   1) Valves.
   2) Chemical Treatment.
   3) Piping Specialties.
   4) Dampers.
   5) Access Doors and Equipment Removal Paths.
   6) Control and Electrical Panels.
   7) Disconnect, Hand/OFF/Auto, and Emergency Power Off Switches.
   8) Temperature / Humidity Sensors and Thermostats / Humidistats.
   9) All control sensors, control panels and required installation distances for access and stable performance.
   10) Mounting Brackets
l. Testing, Adjusting and Balancing devices
m. Controls devices and sensors, including required distances for uninterrupted flows to obstruction
n. Electrical point of connections
o. Controls points of connection
p. Fire Alarm points of connection

4. Drawings shall indicate coordination with work in other Divisions which must be incorporated in mechanical spaces, including, but not limited to:
   a. Irrigation Equipment and Piping.
   b. Elevator Equipment.
   c. Electrical Equipment.
   d. Cable Trays.
   e. Architectural features, including doors and partitions
   f. IT/Electrical outlets
   g. Plumbing equipment
5. Provide sections and elevations for all mechanical rooms, mechanical areas, areas with routed duct mains, areas with routed piping mains, and areas adjacent to the existing structure.
6. Difference or disputes concerning coordination, interference or extent of Work between sections shall be decided by Contractor, his decision, if consistent with Contract Document requirements, shall be final.
7. Provide templates, information and instructions to other Divisions to properly locate holes and openings to be cut or provided.
8. Not all offsets in ductwork or piping are shown. Contractor shall decide which item to offset or relocate. Maintain required slope in piping.
9. Provide wiring diagrams for electrical, controls and fire alarm systems cross referencing panel location/circuit number/point name as appropriate.

H. Substitutions:
   1. In accordance with Section 01 60 00, and where permitted in each section.
   2. Specified products or equipment mean those named on the equipment schedules or identified as Specified Manufacturers herein. All other manufacturers listed are considered substitutions and must meet the requirements of this Section. Only manufacturers identified as Possible Substitutions in this specification may be offered as substitutions for approval.
   3. Substitution requests shall come simultaneous to the relevant submittal and shall not come through the RFI process, unless directed by the Owner's

Representative. The first page of the submittal containing the substitution request shall explicitly include a table of contents identifying the location of the official substitution request paperwork, the table of comparisons, and the supporting data.

4. Submit shop drawings of proposed products that differ from the specified products to demonstrate equivalency of connections and physical arrangements. Show necessary modifications of architectural, structural, plumbing, electrical and mechanical Work required by the proposed products, including relocation of drains, revised electrical circuits, relocation of roof or wall penetrations, and revised foundations.
5. Accompany request for substitution review with table of comparison listing pertinent features of both specified and proposed materials including all scheduled data, material of construction, performance criteria, overall length, width, height dimensions, space required for replacement or maintenance access, motor type, horsepower, voltage, phase service factor, noise levels and controls. This is to be submitted in addition to the index sheet required above for all submittals. Review of proposed substitution will not be made without simultaneous receipt of satisfactory comparison tabulation. The substitution request shall also identify the offered reduction in contract value, which shall be inclusive of all cost associated with work by other trades. If paper copies of data from the referenced manufacturer are provided along with the submitted manufacturer as backup data for the table of comparisons, these shall be explicitly separated via tabs clearly marked as follows:
    a. Substitution request, comparison table, letter sign-off by all affected subcontractors verifying that there is no charge to the project associated with the substitution
    b. Submitted data from requested manufacturer
    c. Reference data from specified manufacturer
6. Limit submittal of substitutions to one proposal for each type or kind of item. If the proposed product substitution is rejected, submit the specified product at no cost to the project.
7. Review of drawings and other material submitted as a substitution shall not be construed as a complete check or constitute a waiver of the requirements of the Contract Documents. This review shall not relieve the Contractor of the responsibility to fit the proposed materials to the spaces provided, and to effect necessary rearrangement or construction of other Work. The submittal response of “No Exception Taken” to a substitution request does not constitute a design change or a direction from the Owner and it is not eligible for a change order request.
8. Any additional work required by other trades as a result of a substitution shall be covered under this Contract, without any additional cost or time delay imposed on the project. Submittals with substitution requests shall include a letter signed by all affected parties (electrical, controls, testing, adjusting, and balancing, general contractor, structural capacity) verifying that the substitution will not incur any additional cost or time delay to the overall project.
9. When a substitution is proposed, the Contractor shall be responsible to ensure that the performance and quality of the scheduled or specified equipment is met. If additional accessories are required to achieve performance, they shall be provided at no cost.
10. Substitutions shall be made explicit during the project buy-out/bid phase (e.g. guaranteed maximum pricing). Selection of the sub-contractor does not imply acceptance of substitutions.

I. Submittals – Checking
   1. Before submitting shop drawings or equipment submittals to the Owner's Representative, the contractor shall check them in detail to be sure that all requirements of the plans and specifications have been fully met.
   2. Incomplete submittals and submittals not in accordance with the above requirements shall be returned without action, and resubmittal shall be required.
   3. Review of drawings and other material submitted shall not be construed as a complete check or constitute a waiver of the requirements of the Contract Documents. This review shall not relieve the Contractor of the responsibility to fit the proposed materials to the spaces provided, to coordinate with the other trades and to effect necessary rearrangement or construction of other Work.
   4. Review is not intended to verify dimensions or quantities, or to coordinate items shown on these Drawings. Review is for general conformance with design concept of the Project and general compliance with the information given in the Contract Documents. Contractor is responsible for dimensions, which shall be confirmed and correlated at the Jobsite, for fabrication processes and techniques or construction, for coordination of his Work with that of all other trades, for installed performance and the satisfactory quality of his work.
   5. Review by the Owner's Representative of Submittals does not release the Contractor from full compliance with the requirements of the plans and specifications when Submittals deviate from these requirements.
   6. Even though Submittals have been stamped "Reviewed" and no exceptions have been taken by the Engineer, the Contractor shall be fully responsible for all unauthorized deviations from the Drawings and specifications. Authorization for deviation will be made only by means of a letter from the Owner's Representative. The Owner's Representative's reviewed "No Exceptions Taken" stamp on a Submittal is not an authorization for a deviation from the plans and specifications.
   7. Any corrections or modifications made by the Owner's Representative shall be deemed acceptable to the Contractor with no change in contract amount unless written notice is received by the Owner's Representative prior to the performance of any work affected by any corrections or modifications.
   8. No material or equipment shall be released for manufacturer or shipment without first obtaining the Owner's Representative approved shop drawings.

J. Resubmittals
   1. Resubmittals shall be reviewed for compliance with the comments made on the original submittal. Clearly identify replies to comments, through a cover letter by the Contractor that lists each comment and the resolution of that comment. Mark with submittal number and date.
   2. Non-compliant items which were not noticed in an earlier submittal but are noticed in a resubmittal shall be noted as non-compliant and the resubmittal tagged for corrective action. The fact that the Owner’s Representative may have overlooked the defect shall not constitute total or partial acceptance of it. The contractor remains responsible for delivering an installation that meets the design intent. All corrective action shall be performed at no additional cost or delay to the project.
   3. Re-submittals shall be complete and shall be explicitly annotated to note all changes. Contractor shall not just include specific responses to review comments, but shall show how the resubmittal data has been corrected and how all consequences of the change have been accommodated.
   4. Changes made in the resubmittal which are not directly a response to an earlier review comment shall be clearly identified on the letter of transmittal provided

with the re-submittal and annotated within the body of the submittal. The reason for the change shall be included.

5. One resubmittal will be reviewed. Review time for all second and higher resubmittals will be charged on a time and materials basis to the contractor regardless of the cause of the resubmittal. This will include all submittals to change manufacturer or equipment type after an original submittal was returned with no exceptions taken, unless the change is directly related to a Bulletin.

1.8 PROJECT RECORD DOCUMENTS

A. In accordance with Section 01 70 00 - Execution and Closeout Requirements: Record Documents, and as follows.

B. Keep up-to-date during the progress of the job through, one set of drawings indicating the Record installation. In addition to changes made during course of Work, show following by dimension from readily obtained base line reference points:
   1. Exact location, type, and function of all valves, dampers, and controllers (cross referenced to valve, damper and sensor/controller charts).
   2. Exact size, invert elevations and location of underground and underfloor piping and ducts, and ducts and piping concealed or exposed in walls.
      a. Dimensional changes to Drawings.
      b. Revision to details shown on Drawings.
      c. Depths of foundations.
      d. Locations and depths of underground utilities.
      e. Revisions to routing of piping and conduits.
      f. Revisions to electrical circuitry.
      g. Actual equipment locations.
      h. Duct size and routing.
      i. Locations of concealed internal utilities.
      j. Changes made by Change Order or Construction Change Directives.
      k. Details not on original Construction Drawings.

C. Underground utility services, both inside and outside of buildings, shall be dimensioned from permanent structures or bend mark. Utility services outside of buildings shall also show depth of burial with reference to the finished ground floor elevation. Mark record prints of Construction Drawings or Shop Drawings, whichever is most capable of showing actual physical conditions, completely and accurately. Where Shop Drawings are marked, show cross-reference on Construction Drawings location.
   1. Mark record sets with red erasable colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location. All notations shall be dated and initialed. Record drawings shall note related change order designations (numbers) on impacted work.
   2. Mark important additional information that was either shown schematically or omitted from original Drawings.
   3. Note alternate numbers, Change Order numbers, and similar identifications.
   4. Responsibility for Markup: Under direct supervision of Contractor, the individual, installer, subcontractor or other entity who obtained record data shall prepare markup on record drawings.
      a. Accurately record information in an understandable drawing technique.
      b. Record data as soon as possible after obtaining it. Record and check markup prior to enclosing concealed installations.

c. Encircle each area of change or additional information with a free-form cloud-shape drawn on the reverse side of the transparency.
d. Identify changes and additional information by printing Change Order Number or other change reference designation, when applicable, within the cloud-shape encircled area.

5. During construction phase, maintain in addition to hard copy, an electronic record document of drawings on CAD file, with 2 back up copies.
6. Transfer markup's from hard copy to CAD files on a monthly basis.
7. Submit one hard copy of changes made to CAD files as part of monthly request for payment,
8. Provide and maintain a list of drawings.

D. A complete progress set of drawings shall be kept on the project site at all times and shall be available for inspection by Owner's Representative or Construction Manager weekly, as a "record" set.

E. Each trade shall submit record copies of their respective shop drawings as part of the project closeout. These record copies shall indicate as-built conditions and shall show all work installed by that trade. All elements shall be dimensioned from grid lines or bench marks and all elevations shall be noted. Construction notes such as component number or conflict notes shall be removed and the drawings shall clearly be noted in the title block as being as-built drawings.

F. Newly Prepared Record Drawings: Prepare new drawings instead of following procedures specified for preparing record drawings where new drawings are required when neither the original Contract Drawings nor Shop Drawings are suitable to show actual installation. New drawings may be required when a Change Order is issued as a result of accepting an alternate, substitution, or other modification.
1. Provide Drawings in a scale that allows for scope of detailing and notations required to record actual physical installation and its relationship to other construction.
2. When completed and accepted, integrate newly prepared Drawings with procedures specified for organizing, copying, binding and submitting record drawings.

G. Submit as a normal submittal, a copy of the completed progress set Drawings and the final draft of the project record drawings to Owner's Representative for approval prior to authorization for final payment. Record drawings shall be certified as to their correctness by the signature of the Contractor and shall be stamped or otherwise identified as record drawings.

H. Prior to Final Acceptance, submit record drawings to the Owner. Organize into sets, and bind and label.

I. At the completion of the project prior to the authorization for final payment, the Contractor shall submit record as-built drawings with numbers of copies as specified under Section 01 70 00 and their electronic CAD files, including all associated reference files, files related to line weights/color for printing, and a PDF print of the intended final drawing product. Drawings shall incorporate all the Owner's comments and corrections, submittal information, RFI information and all addenda and represent completed as-built conditions. Reference to RFI's or Change Orders in lieu of drawing the exact change will not be acceptable. Title block shall explicitly note these as "PROJECT RECORD DRAWINGS" in a prominent location on each drawing.

J. Contractor shall deliver rolls or binders that contain each drawing, whether or not changes and additional information were recorded, such that each copy is a complete as-built representation of the installed work.
   1. Organize hard copies into manageable sets. Bind each set with durable-paper cover sheets. Include appropriate identification, including titles, dates, and other information on the cover sheets.
   2. Organize and bind original marked-up set of prints that were maintained during construction period in same manner.
   3. Submit marked-up progress set, record set, CAD files, and copy sets to the Owner.

1.9 CLOSEOUT SUBMITTALS

A. Operating and Maintenance Instructions and Manuals: Provide number of copies in accordance with requirements of Section 01 70 00 and parallel electronic documentation organized in directories. Additional requirements are parallel to the paper copies. Additional requirements are as follows:

   1. Subsequent to completion of balancing and testing operations, this Division is responsible for instructing the Owner's authorized Representatives in all aspects of operation, adjustment and maintenance of mechanical plant and other mechanical equipment. Provide video documentation of training session on DVD.
   2. Provide a minimum of 8 hours Owner training for each major system (e.g. boiler plant, chiller plant, air handlers, BAS, etc.). Provide a minimum 4 hour Owner training session for the building's non- major systems (e.g. toilet exhaust fans, valves, etc.).
   3. Submit certificate, signed by Owner's Representative, attesting to their having been instructed per Section 01 70 00 and as specified under individual Equipment sections of this specification.
   4. Instructions on major items such as pumps, chillers, boilers, water heaters, water treatment, fans, air handlers, and temperature control shall be by representative of manufacturer of the respective equipment.
   5. Schedule training with Owner's representative a minimum of 5 working days in advance. All Owner training shall be completed prior to scheduling final inspection.
   6. One month prior to request for final inspection, submit Operating and Maintenance manuals and electronic documentation under Section 01 70 00.
   7. Manuals shall be prepared to ASHRAE Guideline 4-2008. The manuals shall be predominately typewritten with occasional printing or hand-drawn demarcations and notes. Shall include the following in the Equipment Binder(s):
      a. Section 1: Overview documents:
         1) A comprehensive table of contents and guide to the manuals contents and layout. This section shall enable the reader to comprehend the scope and purpose of the document and to identify readily where specific information can be obtained.
         2) Equipment List: List of all major equipment as installed. Include tag reference model number, normal capacities, location in building, and location tab number in Section 3 binders.
         3) Manual valve charts organized on a room and sequence basis, identifying room, system, valve numbers, valve type, valve usage, and associated equipment.

4) Manual fire and fire smoke damper charts organized by type on a room and system basis, detailing room system and damper number.

b. Section 2: Contractual and Legal Records including:
   1) Name and Address of the installation.
   2) Contact Name and telephone number for emergency repairs.
   3) Details of City and State approvals.
   4) Name and Contact details of the Design Team and Installing Contractors and associated sub-contractors.
   5) Copies of maintenance service contracts and contact details for local service company.
   6) Master Equipment List containing Dates for Start of Installation, Substantial Completion, and Expiry of Warrantee period.
   7) Copies of warrantees, guarantees and bonds.

c. Section 3: Individual Equipment Sections:
   1) Startup and Shutdown Procedures:
      a) Provide a step-by-step write-up of all major equipment. When manufacturer's printed start-up, troubleshooting and shut-down procedures are available, they shall be incorporated into the operating manual for reference.
   2) Operating Instructions: Written operating instructions shall be included for the efficient and safe operation of all equipment.
   3) Service Instructions: Provide the following information for all pieces of equipment:
      a) A detailed parts list
      b) Recommended spare parts, including catalog number and the name, manufacturer’s name and contact information, address and telephone number of local suppliers of factory representative.
      c) Lubrication and maintenance instructions and recommended service maintenance schedule for all equipment including all electric motors. Sample maintenance record forms for each equipment type.
      d) A lubrication chart listing each item of equipment, all points of lubrication, proper lubricant, dates lubricated, and lubrication schedule.
      e) Belt sizes, types and lengths – adjustments made to install systems.
   4) Data sheets to show model number, capacity, nameplate data, complete internal wiring, mechanical and electrical ratings and characteristics, catalog data on component parts whether furnished by equipment manufacturer or others, names, addresses and telephone numbers of source of supply for parts subject to wear or electrical failure, and description of operating, test, adjustment, and maintenance procedures.
      a) Where data sheets included in the manual include equipment, options, or other features not part of equipment actually furnished, line out these references or otherwise clearly mark so remaining text, diagrams, drawings, schedules, and similar information shall apply specifically to equipment furnished.
      b) Parts catalog references for each item of equipment furnished with components identified by number for replacement.
      c) Final submittals for equipment shall have final corrections included in the points used for the manual.

5) Testing and Balancing reports:
   a) Sheets detailing all set points, and final balance figures of air and water systems.
   b) Cross-reference diagrams in plan to identify air terminals and equipment location.
   c) NC levels by room
   d) Pressurization testing results (as applicable).

d. Section 4: Controls:
   1) Title index tabs identifying items therein.
   2) Detailed list of all sensors, devices, and controllers cross reference to control set points names. List shall cross reference physical location in building, control and wiring diagrams and documentation in this section.
   3) Software name/version and support contact information.
   4) Detailed description of sequence of operation of each system, with charts and diagrams. Include emergency operation performance and resetting procedures as appropriate. Include explicit definition of all setpoints, alarm triggers, loop tuning coefficients, and ranges present within programming at time of handover.
   5) Provide full size copies of Record one-line diagrams and plans, thin laminated and folded into plastic envelopes for inclusion in the binder.
   6) Provide laminated control diagrams. Diagrams shall show complete equipment, controls, model numbers, etc., marked to correspond to identification on equipment.

e. Section 5: Certifications:
   1) Title index tabs identifying items therein.
   2) Certificates: Submit final inspection certificates signed by governing authorities.
   3) Letters from manufacturers certifying their supervision of equipment installation and start-up procedures.
   4) Machinery vibration test reports.
   5) Room NC levels at handover as tested by an acoustical engineer.
   6) Test certificates.
   7) Instruction certificates.
   8) Inspection certificates.
   9) Fire Marshal and/or Fire Department approvals of system.
   10) Final inspection certificate signed by governing authorities.
   11) UL, ASME and ASTM rating certificates (as appropriate).
   12) Air Quality Management District certification of boilers.
   13) Other certification as noted in other Division 23 sections.

f. Section 6: Record As-Built Drawings: Submit drafts of service and maintenance instruction sheets to Owner's Representative for review before preparing final sets.

g. Section 7: Video documentation of training sessions

h. Section 8: O&M Manual as electronic versions

1.10 WARRANTY

A. Conform to the requirements of Section 01 70 00 - Execution and Close Out Requirements and Warranties

B. Unless otherwise noted within a particular section, under special warranty each complete system shall be warranted by the Contractor for the period referenced in 01 70 00. Each system shall be free of defects of materials and workmanship, and shall perform satisfactory under all conditions of load or service. The warranties shall provide that all additional controls, protective devices or equipment provided as necessary to make the system or equipment operate satisfactorily and than any faulty materials or workmanship shall be replaced or repaired. On failure of the warrantor to do the above after written notice from Owner, the Owner shall have the Work done at the cost of the warrantor. Loss of refrigerant is considered a defect in workmanship and/or equipment, to be corrected at no extra cost to the Owner.

C. Provide new materials, equipment, apparatus and labor to replace that determined by Owner to be defective or faulty within the warranty period.

D. This guarantee also applies to services including Instructions, Testing, Adjusting, Balancing, Noise and Commissioning.

E. Furnish Manufacturers' standard Warranties in excess of the period referenced in Section 01 70 00, only as specifically required under the individual equipment section.

F. Unless otherwise noted, warranties shall commence upon the Owner's final acceptance of the project.

1.11 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

C. Nothing in these plans or specifications is to be construed to permit work not conforming to the prevailing codes and regulations. Should there be any direct conflict between any referenced standard and the governing code, the mandatory code language shall govern to set only the minimum requirements and the most stringent requirement shall govern. A letter or Request for Information (RFI) shall be generated to highlight the discrepancy.

D. Install Work by craftsmen skilled in the trade involved and by apprentices as indicated in the General Conditions.

E. The Contractor recognizes that the design is based upon the equipment and material specified by name or construction and the Contractor accepts full responsibility for assuring that the quality, utility and performance of a substitution equals or exceeds that of the specified item.

F. Electrical Testing: Provide the services of a qualified testing laboratory/agency to perform the specified field tests. Notify the Owner's Representative 24 hours in

advance of performance of Work requiring testing. Provide all materials required for testing. Refer to Division 26 for detailed requirements of electrical testing.

G. Factory and Field Testing
1. See each Section for the required testing and procedures.
2. Provide the services of a qualified testing laboratory/agency to perform the specified field tests.
3. Notify the owner's representative at least 72 hours in advance of tests.
4. Provide all materials required for testing.
5. Test reports shall include:
   a. Description of equipment tested.
   b. Description of test procedures.
   c. Test results.
   d. Names and signatures of witnesses of tests.

H. Performance testing
1. Upon completion of the Work and following adjustment of all equipment, conduct an operating test for each system's acceptance. Demonstrate all systems and equipment to be operational and free from all electrical and mechanical defects.
2. Notify the Owner's Representative fourteen days in advance of when tests will be performed. At that time, provide a test procedure plan, test schedule and test procedure forms.
3. Coordinate the work of Performance Testing with the Commissioning Requirements for Pre-Functional and Functional Testing.

I. Any appliance for which there is an ASHRAE 90.1 standard established regarding appliance efficiency shall comply with the applicable standard.

J. Materials and Workmanship
1. Materials shall be new, meet detailed requirements of the contract document and be identifiable as being specified or substitute products. Materials shall be kept in original packing material and protected from the elements by plastic and placed on dunnage until the item is installed. Once installed, all electrical devices exposed interior materials and all insulation installed shall be covered with sealed plastic until the building is fully enclosed and all spraying applications are complete.
2. Materials that do not conform to the requirements of the contract documents, are not equal to approved samples or are unsatisfactory or unsuited to the purpose for which they are intended, will be rejected and shall not be installed.
3. All work shall be performed by properly licensed plumbers, mechanics, and technicians with work limited to their respective trades.
4. All equipment shall be installed in accordance with the recommendation of the manufacturer. Use printed descriptions, specifications and recommendations of manufacturers as a guide for installation of Work.
5. Defective work, whether the result of poor workmanship, use of defective materials, damage through carelessness, or other cause shall be removed within ten (10) days after written notice is given by the Owner's Representative, and the work shall be re-executed by the Contractor. The fact that the Owner's Representative may have previously overlooked such defective work shall not constitute acceptance of it.
6. In no case shall a Bidder base his bid on a class of material or workmanship less than that required by the contract documents and the governing codes and ordinances.

7. Materials and adhesives used throughout the mechanical systems for insulation, filters, ducts, flexible connections and jackets or coverings regardless of kind for piping and ducting system components, shall have a flame spread rating not over 25 without evidence of continued combustion and with a smoke developed rating not higher than 50. "Flame Spread Rating" and "Smoke Developed Rating" shall be as determined by the "method of test of surface burning characteristics of building materials, NFPA No. 244, ASTM E84, Underwriters Laboratories, Inc., Standard". Such materials are listed in the Underwriters Laboratories, Inc., "Building Materials List" under the heading "Hazard Classification (Fire)".
8. Equipment shall be approved for use by all relevant Authorities Having Jurisdiction, where applicable.
9. Equipment required to have test labels by requirements of individual equipment sections shall have labels permanently affixed.
10. Manufacturer's nameplate, name or trademark shall be permanently affixed to all equipment and material furnished under this Specification. The nameplate of the Subcontractor or Distributor is not acceptable.

K. All Base Materials: Comply with standard ASTM and ANSI.

L. All Pressure Vessels, Relief Valves, Safety Relief Valves and Safety Valves: Comply with standards, ASME stamped.

M. All Electrical Devices and Wiring: Conform to standards of NEC. All devices: UL listed and identified.

N. Applicator (Erector) Qualifications:
1. All equipment and accessories shall be the product of a manufacturer regularly engaged in its manufacture.
2. All equipment and accessories new, free from defects.
3. Supply all equipment and accessories in compliance with the applicable standards listed in this Section and with all applicable national, state and local codes.
4. All items of a given type shall be the product of the same manufacturer.
5. Electrical equipment: Listed by UL and bearing their label.

O. Checking and Testing Equipment By Contractors and Manufacturer's Representative
1. All equipment shall be installed per the manufacturer's instructions. During construction request supervisory assistance from equipment manufacturer's representatives so the equipment will be correctly installed. After installation, request the Owner's Representative to inspect and see the equipment is in proper working order.
2. Manufacturer's representative shall review the overall system design relative to the proper application of his equipment in the particular system. He shall note conduit, wiring, control, location, and other relevant relationships, and furnish appurtenances necessary for satisfactory operation.
3. Before equipment start up, the manufacturer's representative shall submit to the Owner's Representative, a signed statement certifying to their inspection and noting that the equipment is properly installed and ready for operation.

1.12 PRE-INSTALLATION MEETINGS

A. Section 01 30 00 - Administrative Requirements: Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.13 PROTECTION, DELIVERY, STORAGE, AND HANDLING

A. Conform to the requirements specified in Section 01 60 00 - Product Requirements.

B. Contractor to provide an authorized representative to constantly supervise Work of this Division, check all materials prior to installation for conformance with Drawings, Specifications, and reviewed Shop Drawings.

C. Delivery
1. Deliver materials or equipment to the Project in the manufacturer's original unopened, labeled containers and adequately protect against moisture, tampering or damage from improper handling or storage, ingress of dirt or contamination of any kind. Do not deliver materials to the job before they are ready for installation, unless adequate security is provided.
2. Perform all handling and shipping in accordance with manufacturer's instructions.
3. All ductwork shall be delivered to site with all ends and openings capped with heavy gauge polythene sheeting taped all around to prevent ingress of moisture, dust, and debris.
4. Deliver equipment in its original package to prevent damage or entrance of foreign matter. Perform all handling and shipping in accordance with manufacturer's recommendations. Provide protective coverings during construction.
5. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

D. Identification
1. Identify materials and equipment delivered to Site to permit check against approved materials list, reviewed Shop Drawings. Identify materials and equipment by manufacturer's name, tag reference and nameplate data. Remove unidentified materials, equipment from Site.

E. Loss or Damage
1. All materials, appliances, and equipment shall be new and free from defects, and of the make, brand or quality specified or as accepted by the Owner. All materials and equipment shall be installed in a neat and workmanlike manner. Any work not so installed shall be removed and replaced in a satisfactory manner at no charge to the Owner.
2. Equipment or material damaged during transportation, installation or operation is considered as totally damaged. Replace with new. Variance from this permitted only with written acceptance.
3. The Contractor shall replace lost or damaged materials and equipment with new at no increase in Contract Sum.

F. Storage

1. All stock-piled material shall be placed on pallets, and protected from weather and from entry of foreign material and construction dust by plastic. All stored materials and equipment shall be carefully inspected and cleaned prior to installation and replaced with new material or equipment if found to be damaged, corroded, etc.
2. Equipment which is observed to be exposed to the weather, dirt or construction debris can be interpreted by the Owner's Representative as defective equipment under this clause.
3. All stored materials and equipment shall be carefully inspected prior to installation and replaced with new material or equipment if found to be damaged or corroded.
4. Completely cover motors and other moving machinery to protect from dirt and water during construction, including after installation.
5. Cap all openings in pipe and ductwork daily to protect against entry by foreign matter.
6. Store plastic pipes protected from direct sunlight. Support pipe to prevent sagging and bending.
7. Protect all finished surfaces of fixtures and exposed to view materials with heavy plastic or by other means, throughout the period of construction.

G. Waterproof Construction
1. Maintain waterproof integrity of penetrations of materials intended to be waterproof. Provide flashings at exterior wall and roof penetrations. Caulk watertight penetrations of foundation walls, above grade walls, roofs, and floors. Provide membrane clamps at penetrations of waterproof membranes.
2. Provide galvanized sheet metal weather protection canopies, hoods or enclosures over all out-of-doors equipment, the operation or maintenance of which would be impaired by rain water. This requirement applies to damper operations and bearing, damper motors, controls and instruments. See other paragraphs in this Division for application of this requirement to motors, drive, ducts and fans.
3. If ductwork, piping, insulation or any damper or valve is installed in a riser prior to the permanent roof construction of that riser is complete, provide auxiliary sheet metal, drain piping, and caulking to ensure watertight caps on all temporary riser top openings that occur during the construction process. Take responsibility to ensure that watertight protection is provided continuously except when actual work is being done at the opening.

1.14 TEMPORARY FACILITIES

A. Temporary Water: Provided under Section 01 50 00.

B. Temporary Light and Power: Provided under Section 01 50 00.

C. Temporary air-conditioning: Provide conditioning sources for use during construction that are independent of the building's air handling systems. Building air handlers shall not be used during construction unless explicitly approved for use by the Owner's Representative.

D. Temporary heating and ventilation: Provide heating and ventilation sources for use during construction that are independent of the building's air handling systems. Building

air handlers shall not be used during construction unless explicitly approved for use by the Owner's Representative.

E. Where retrofit work to the requires that the equipment is taken off line, the contractor shall provide temporary cooling, heating, humidification, air-conditioning facilities to ensure continuous building operation in the areas occupied during construction. All such switchovers to temporary cooling and heating shall be scheduled and coordinated with the Owner's Representative at least one month prior to the event. The Work may require shutdowns to be accomplished on an "overtime" basis without additional cost to the Owner.

F. Where retrofit work requires connection to the central plant or other building plant, the contractor shall complete the work prior to the connection with the plant to minimize the impact of the plant shutdown (e.g. time or cost), subject to the requirements of the Owner.

G. Assume responsibility for chemical treatment and freeze protection during use of temporary facilities.

H. All temporary facilities shall be removed at completion of project, with permanent facilities returned to proper working order.

1.15 COORDINATION

A. Section 01 30 00 - Administrative Requirements: Coordination, Field Engineering, Electrical Characteristics, Cutting and Patching.

B. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

C. Cooperate with all other Divisions performing work on this project as necessary to achieve a complete neatly fitted installation for each condition. Consult the Drawings and Specifications to determine nature and extent of work specified in other Divisions that adjoins, shares space with, or attaches to the work of this Division. Confer with other Divisions at the site to coordinate this work with theirs in view of job conditions to the end that interferences may be eliminated and that maximum headroom and clearance may be obtained. In the event that interferences develop, the Owner's Representative's decision will be final as to which Division shall relocate its work, and no additional compensation will be allowed for the moving of piping, ductwork, conduit or equipment to clear such interferences.

D. For Testing and Balancing of the system, ensure full co-ordination between the Testing and Balancing subcontractor and all other Trades to achieve access to all system components including leaving wall/ceiling sections down for access.

E. Coordination with Structural Work
   1. Schedule of Work: In accordance with Division 01 - General Requirements and as follows:
      a. Arrange work to conform to schedule of construction established or required to comply with Contract Documents.

b. In scheduling, anticipate means of installing equipment through available openings in structure.
c. Ascertain temporary openings required for admission of apparatus. Notify the General Contractor and Architect accordingly. Provide such openings at no additional cost to the Owner.

2. Openings and penetrations are prohibited in structural members, except where shown or as directed by the Owner's Representative and the building's Structural Engineer in writing.
3. At the start of the project, meet with the Owner's Representative to obtain information regarding allowable sleeve or penetration spacing and size.
4. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
5. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
6. The Contractor shall be responsible for being aware of the nature and arrangement of the materials and construction to which the work attaches or passes through, and shall propose support and penetration details that are consistent with maintaining the integrity and performance of the construction such as, but not limited to, fire-resistive construction, acoustically rated construction, vibrated isolated construction, water tight construction, fire proofed construction, and isolated construction.
7. The Contractor shall do all cutting, sleeving, core drilling and carpentry of building materials, piping, etc., as required for the installation of work and in accordance with Section 01 73 29.
8. All cutting shall be performed with machine saw. Holes for pipes in concrete walls or floors shall be drilled with core drilling equipment. Verify location of all such cutting or core-drilling with the structural engineer prior to execution.
9. Where any Mechanical work cannot be installed as the work progresses, the Contractor shall provide and arrange for the building in of boxes, sleeves, inserts, fixtures or devices as necessary to permit installation of the omitted work during later phases of construction. This field coordination work shall be completed prior to structural shop drawings and shall follow the principles set forth in the meeting reference above. Arrange for and lay out any chases, holes, or other openings that must be provided in masonry, concrete or other work.
10. This work shall be incorporated into the initial shop drawing review of the construction (wall, floor, etc.) that is affected so that the Owner's Representative may review the impact of the holes.
11. Once the structural shop drawings are returned with no exception taken, the contractor shall bear the cost of time and materials for the Owner's Representative to review the appropriateness of cutting or drilled holes in planned or existing construction.
12. The Contractor shall be responsible for ensuring that all openings shown on the drawings or otherwise required are provided by the relevant trade contractor during the construction of the wall or roof.
13. No structural members shall be cut without the prior approval of the Owner's Representative. To gain approval to cut concrete, X-ray the affected area (or use another non-destructive method to examine the affected area) and submit results to Structural Engineer for review. Submit to Owner's Representative, drawings and details for the support of structure around the opening. If the standard structural details are to be used, then submit a plan that cross-references all penetrations against detail numbers for review. Otherwise, submit drawings, design, and calculations stamped by a Registered Professional Structural

Engineer. Any cutting and remedial support shall be done in a manner satisfactory to the Owner's Representative.

14. Where openings break into an existing wall, the Contractor shall provide lintels as required for the support of building construction above the opening. Lintels shall be structural steel angles, channels or tees of proper size and sections for the supported load. The Contractor shall submit structural load calculations to the Owner's Representative signed and sealed by a professional engineer prior to installation.
15. The contractor shall bear the cost of time and materials for the Owner's Representative to re-analyze the construction if the original penetration spacing principles are not adhered to, for whatever reason.

F. Cutting And Patching

1. Patching of building structure, walls, floors, etc. during normal work progress with Requirements of Section 01 33 00.
2. All patching of or repair of damage to completed work in place shall be done to meet with the approval of the Owner's Representative.
3. Work in place that is subsequently cut is seen as evidence of the contractor's lack of field coordination during the shop drawing production phase. Because field coordination is a requirement of the contract, the contractor must bear all costs of cutting, patching and repair for corrective work.
4. Assume responsibility for damage to any part of premises or Work of other Divisions, caused by leaks or breaks in piping or equipment furnished or installed under this Division during construction and guarantee/warranty period.
5. Provide sleeves, caps, plates, escutcheons, flashing, etc., required to fill or close the openings. Provide final grouting, concrete, asphalt, masonry, painting and other materials as required. Make repairs in like and kind for exact patching or surfaces and finishes.
6. Where cutting and patching occurs in streets, sidewalks, alleys and the like, cooperate fully with Owner's Representative and municipal or other government bodies.
7. All patching shall be equal to the condition of the element prior to cutting as defined by the Owner's Representative.

G. Coordination with Electrical Work

1. Division 26 Contractor: Wire all mechanical equipment furnished by this Division (excluding internal factory wiring) in accordance with the following general provisions:
    a. Provide 120-volt emergency power circuits available at panel for control contractor's use.
    b. Provide and wire heavy-duty, quick-make, quick-break type disconnect switches, manual pushbuttons and other fire alarm hard-wiring specifically called for in the documents or noted in electrical specifications and wherever required by Code. This excludes factory-mounted disconnects on equipment.
    c. Receive, unload, set, and rough align all separately shipped motors.
    d. Receive, unload, set and install all motor starters and variable frequency drives, except those clearly specified as an integral piece supported on the body of a piece of equipment.
    e. Wire all miscellaneous solenoid valves, relays and other components provided with equipment which is not factory wired or part of control contractor's scope.

f. Wire lighting controls and other monitoring systems for interface with Building Management and Control System.
g. Wire interlocks between equipment as called for in Controls specifications.
h. Provide final equipment power connections for all equipment with voltage 110-volt and greater, including overcurrent protection and disconnect.
i. Provide final equipment connections for all equipment that require motor starters. Include starter, overcurrent protection, and disconnect.
j. Provide final connection to motorized smoke and fire-smoke dampers with voltage 110-volt and greater.
k. Provide 120V wiring and conduit from Electrical Panel to dedicated J-boxes located for controls Contractor's exclusive use.
l. Provide 120V wiring and conduit from dedicated J-box to Control Panels or controllers. Provide a disconnect switch for each final connection.

2. Division 23 shall provide the following:
   a. All motor starters and variable frequency drives or control devices called for to be factory prewired to mechanical equipment.
   b. All control devices noted on the drawings and within the specifications, including devices required to achieve Sequences of Operations but not explicitly mentioned or called out. Provide controls, controllers, relays, transformers, switches, etc. required by Work of this Division 23 - Heating, Ventilating, and Air-Conditioning (HVAC).
   c. Complete and accurate wiring diagrams to Division 26 for all equipment requiring electrical power wiring.
   d. Information for separately shipped motors and variable frequency drives to be installed by Division 26. Adjustable motor bases and all bolts and nuts required for installation of base and motor shall be provided and installed by Division 23.
   e. Align and adjust mechanical coupling for direct-driven motorized equipment. Adjust and align drive and belt tension on belt-driven equipment.
   f. Field lubricate all motors prior to operation and maintain lubrication prior to acceptance of equipment by the Owner's Representative.
   g. Provide motor terminal connection diagram as prepared by motor manufacturers.
   h. Provide low- voltage (less than 100V) control wiring from Control Panel or controller to controlled device.
   i. Electrical work in this Division shall conform to the requirements of Division 26.
   j. Provide controls relay for Building Automation System's position monitoring of motorized smoke and fire-smoke dampers (in coordination with Division 28).
   k. Equipment shall be ordered with factory-wired assemblies or panels, pre-wired to numbered terminal strips for connection to field wiring.
   l. Provide weather-proof devices or protection for equipment outdoors, regardless of installing party.
   m. Contractor to coordinate piping routing to ensure piping does not run above electrical equipment.
3. Division 28 Contractor: Wire all mechanical equipment furnished by this Division in accordance with the following provisions:
   a. Product of combustion (duct smoke) detectors to be furnished under Division 28. Damper and duct smoke detectors to be installed by Division 23. Duct smoke detector to be wired by Division 28 to the fire alarm system.

b. Provide hard-wired air handling equipment shut-down relay connection as required by code.
c. Provide hard-wired connections for smoke control systems.
d. Provide hard-wired connections for control to all motorized smoke and fire-smoke dampers.
e. Provide fire alarm system position-monitor wiring for all motorized smoke and fire-smoke dampers.
f. Provide Fire Alarm location signals to the Building Management System, as applicable.

4. Where Drawings clearly and explicitly differ from the preceding wiring paragraphs, Drawings have precedence.

H. Commissioning Responsibilities
1. Carry out commissioning requirements per sections 23 08 00 and 01 91 13 for data collection for Pre-Functional and Functional testing.
2. Provide mechanical technical support and controls services to assist the Commissioning agent to manipulate the control system during Functional Testing.
3. Provide testing adjusting and balancing services to assist the Commissioning agent to provide diagnostic measurements during Functional Testing.

I. Sustainable Design Intent:
1. Comply with project requirements intended to achieve sustainable design, measured and documented according to the Massport Sustainable Design Standards and Guidelines. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 GENERAL COMMENTS ON MATERIALS

A. Equipment specified by manufacturer's number shall include all accessories, controls, etc., listed in catalog as standard with equipment. Furnish optional or additional accessories as specified.

B. Where no specific make of material or equipment is mentioned, an RFI shall be submitted suggesting any first class product of reputable manufacturer selected at the Contractor's discretion, provided it conforms to requirements of system.

C. All items of materials in each category of equipment shall be of one manufacturer.

D. Equipment shall be as described in the respective Sections of Division 23 - Heating, Ventilating, and Air-Conditioning (HVAC) and as shown.

E. Design of mechanical systems is generally based on the product of one of the manufacturers cited. Where systems for product installed necessitate modification of

systems shown on plans, Contractor is responsible for installation of systems appropriate to product installed.

2.2 MANUFACTURERS

A. In other Division 23 specifications, the following applies in Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified. The first manufacturer listed first represents the basis of design as scheduled and drawn in the Construction Documents.

PART 3 - EXECUTION

3.1 LOCAL AND EXISTING CONDITIONS

A. Prior to bidding, visit the site and determine all existing conditions affecting work in this Division and make adequate provisions in the bid proposal. Examine all Drawings and Specifications to familiarize with the type of construction to be used, and the nature and extent of work of other trades.

B. Observe the conditions under which deliveries of materials and equipment shall be made and under which such materials and equipment can be stored, and shall include adequate provision in the bid proposal.

C. Anticipate means of installing equipment through available openings in structure and make adequate provisions in the bid.

D. The location and elevation of the utilities, existing ductwork, piping, conduit, or equipment is that which can be determined from available information and its accuracy cannot be guaranteed. Exact location and elevation of these items shall be verified by the Contractor prior to excavation, demolition, or installation of any portion of the work indicated. Exercise special care when excavating at or near the general location of underground utilities to avoid damage to the utility services, as well as to ensure worker safety. Protect existing active services (water, gas, sewer, electric) when encountered, against damage from construction work. Do not prevent or disturb operation of active services which are to remain.

E. Any connections to or relocation of any existing utility line requiring temporary discontinuance of utility services which are in active use shall be scheduled and coordinated with the utility companies and the Owner's Representative at least 10 working days in advance. Provide description of disconnect, procedure to be done, and date/time duration of shutdown. The Work may require shutdowns to be accomplished on an “overtime” basis without additional cost to the Owner. Arrange work for continuous performance to assure that existing operating services will be shut down only during the time required to make necessary connections. If a system cannot shut down, install temporary bypasses or jumpers until connections are complete. In no case shall the services be left disconnected at the end of a working day or weekend

unless authorized by representatives of the utilities and the Owner's Representative. Any existing utility service damaged shall be repaired to the satisfaction of the Owner's Representative.

F. If existing active utility services are encountered which require relocation, make request proper authorities for determination of procedures. Properly terminate existing services to be abandoned in conformance with requirements of authorities having jurisdiction.

G. All removed equipment shall remain the property of the Owner and stored on site as directed.

H. Where connections or disruptions are made to existing system, reactive, refill and recharge all components and restore systems to the same operating conditions prior to the time of disruption.

I. Equipment Rough-In:
   1. Rough-in locations shown on Mechanical Drawings for equipment furnished by Owner and for equipment furnished under other Divisions are approximate only. Obtain exact rough-in locations from following sources:
      a. From Shop Drawings for Contractor furnished and installed equipment.
      b. From Architect for Owner furnished-Contractor installed equipment
      c. From existing equipment where such equipment is relocated under this Contract
   2. Verify mechanical characteristics of equipment before starting rough-in. Where conflict exists between equipment and rough-in shown on Drawings obtain clarification from Architect and provide as directed at no increase in Contract Sum.
   3. Make final connections.

3.2 FIELD VERIFICATION

A. All dimensions, locations of equipment and connections to utilities or pre-existing equipment shall be verified in field prior to construction and installation.

B. Architectural plans will hold precedence over mechanical plans as to location of partitions and diffusers.

C. Measurements in existing buildings shall take precedence over all other plans with regards to identifying location of existing installations.

D. All roughing in construction dimensions shall be made from architectural plans where discrepancies may exist. No change orders will be allowed for shifts in mechanical piping, ductwork, or equipment to match rough-in hole locations within 10 feet of original mechanical drawings.

E. Mechanical plans shall take precedence over electrical and plumbing plans with regards to placement of mechanical equipment and layout of electrical and plumbing equipment within rooms designated as "mechanical rooms."

3.3 HOIST, RIGGING, TRANSPORTATION AND SCAFFOLDING

A. Provide all scaffolding, staging, cribbing, tackle hoist and rigging necessary for placing all materials and equipment in their proper places in the project. All temporary work shall be removed from the premises when its use is no longer required.

B. Prior to placing equipment or scaffolding, the contractor shall provide written verification that the structure on which the load is imposed has sufficient strength to accommodate the point and/or line loads.

3.4 PREVENTION AND RESTORATION OF DAMAGE

A. Protect premises and Work of other Divisions from damage arising out of installation of Work of this Division.

B. Perform Work in manner precluding unnecessary fire hazard.

C. Repair and replace work installed by this Division when it becomes damaged.
1. Wetted insulation shall be considered damaged.
2. Any NEM1 or NEMA2 motors for actuators that is wetted shall be considered damaged.
3. Any metal showing evidence of rust, white rust, or other corrosion shall be considered damaged.
4. Any caulking or adhesive which is observed to be flaking, delaminating or otherwise appearing to lose its bond shall be considered to be damaged, even if no evidence of actual leakage is as yet available.
5. Any device or material exposed to fire or fire-generated smoke shall be considered damaged. This excludes localized use of controlled welding equipment for installation.
6. Any device or material not in compliance with the Construction Documents shall be considered damaged.
7. Ductwork, insulation and piping which shows evidence of denting, bending or compression greater than 1/8” deep shall be considered to be damaged. Any of these items showing evidence of having walked on will be considered damaged with replacement of the affected part and a 10’ length on either side of the main damaged area.

D. Repair or replace, as directed by Owner’s Representative, materials and parts of the Owner’s premises which become damaged as result of installation of Work of this Division. Remove replaced parts from premises.

E. Contractor shall be responsible for repair to work of all other Divisions caused by installation of the work of Division 23 or by leaks from piping or equipment furnished or installed under Division 23 during construction and guarantee/warranty period.

F. Where damage to another trades work occurs the Contractor shall pay the relevant trade contractor to make the repairs.

G. All repairs shall be equal to the condition of the element prior to cutting as defined by the Owner’s Representative.

H. Review of Construction
   1. Work may be reviewed at any time by the Owner's Representative.
   2. Advise the Owner's Representative that work is ready for review at following times:
      a. Prior to backfilling buried work
      b. Prior to concealment of work in walls and above ceilings.
      c. When an area or section of work is ready for punchlisting by the Owner's Representative.
      d. When all requirements of Contract have been completed.
   3. Maintain on job a set of Specifications and Drawings for use by Owner's Representatives.
   4. The Owner's Representative will provide field observations of construction, will inform the Owner regarding progress and problems related to construction, and will endeavor to guard the Owner against defective materials and faulty workmanship. Field observations will be periodic depending upon nature of construction. The Owner's Representative does not perform an extensive or continuous inspection, is not responsible for execution of Contract Documents by Contractor, and is not responsible for construction methods, sequences, or safety precautions.

3.5 TOOLS AND EQUIPMENT

A. Furnish all tools and equipment necessary for the proper installation, protection and upkeep of the work.

B. Furnish to Owner the following:
   1. One set of any special tools required to operate, adjust, dismantle or repair any equipment of this Division. "Special Tools" means those not normally found in possession of mechanics or maintenance personnel.
   2. One pressure grease gun for each type of grease required, complete with adaptors to fit all lubricating fittings on equipment.

3.6 EXCAVATION, TRENCHING AND BACKFILL

A. Coordinate trenching and backfill required for the installation of this Division as detailed in Section 31 23 16 and 31 23 17. Repair or replace all street, roadway, sidewalk, pavements, gutters, curbs and other work incidental thereto. Dispose of excavation material per Division 31.

B. Provide barricades, signs, lanterns, shoring, sheeting and pumping as part of Work in this Division as required to insure safe conditions. Comply with OSHA requirements.

C. Shore all trenches and excavations as necessary to maintain the banks of excavations and to prevent any sloughing, caving-in or damage of any kind.

D. Perform all excavations, trenching, and backfill required to complete the work in this Division, regardless of the character of the materials encountered or the method of excavation required.

E. All excavations shall be inspected by the Owner's Representative and approved before placing of any pipe, conduit or duct.

F. Subject to the requirements of the civil engineer, dig trenches straight, true to line and grade with sides and bottoms smoothed of any rock points. Excavate 6 inches below grade of pipe, fill with sand properly packed. Support pipe for entire length on packed sand. Shape of pack bottom of trenches for pipe, duct fittings, hubs, couplings, etc., using templates to fit outside periphery of lower third of piping and ductwork. Provide piping outside building with 36 inch minimum cover from top of pipe to finished grade. Minimum width 16 inches.

G. All pipe, duct or conduit installation shall be inspected by the Owner’s Representative and the Authority Having Jurisdiction prior to backfill.

H. Pumping equipment shall be provided as necessary to keep trenches free from standing water. All shoring necessary to maintain the banks of excavations and to prevent any sloughing or caving-in, and as necessary to prevent damage of any kind which may occur in connection with this work shall be furnished and installed by the Contractor.

I. In any asphalt or concrete paved areas, backfill only to subgrade level, as coordinated with Division 31 Contractor.

J. Utility trenching shall comply with individual utility company requirements.

K. Any imported backfill material required shall be approved by the soils engineer responsible for certification of compaction.

3.7 INSTALLATION

A. Install equipment according to the manufacturer’s instructions, code requirements, and required access clearances.

B. Equipment Installation
1. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
3. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
4. Install equipment to allow right of way for piping installed at required slope.
5. Assemble equipment which is required to be field assembled under the direct supervision of the manufacturer’s agent. Prior to the final acceptance submit letters from the manufacturers that this has been done.
6. Accurately set and level with supports neatly placed and properly fastened. Properly fasten equipment in place with bolts to prevent movement in earthquake. No allowance of any kind will be made for negligence on part of Contractor to forsee means of bringing in, installing equipment into position inside building.

C. Vibration and Seismic Control
   1. Coordinate with Division 1.
   2. Design criteria and extent of bracing, anchorage, etc., for all the Work of Division 23 - Heating, Ventilating, and Air-Conditioning (HVAC) are specified in Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment and Section 23 31 00 - HVAC Ducts and Casings.

D. Hangers, Inserts, Supports and Bases
   1. Provide required structural members, hangers, supports and inserts to keep piping and conduit in proper alignment and prevent transmission of injurious thrusts and vibrations. Where supported from concrete construction, do not weaken concrete or post-tension strands or penetrate waterproofing. Hangers and supports shall be finally adjusted in vertical and horizontal direction under operating conditions.
   2. Metal deck roof systems shall not be used for the support of hangers, inserts, etc.
   3. Support equipment and other mechanical items on curbs, legs or steel framework. Provide all metal bases and supports, not part of the building structure, unless specifically indicated to be provided under this Division shall be as described for similar work under other Division. Materials and equipment furnished or provided under this Division shall be as described for similar work under other Division. Concrete, masonry and wood bases and supports shall be provided under other division of this Specification. Furnish required foundation sizes, bolts, washers, sleeves, plates, templates, etc., for mechanical equipment provided.
   4. Coordinate inserts with Division 3 prior to pouring of concrete. In the infrequent event that an insert is dislodged or misplaced, provide a request for information that includes a precisely dimensioned drawing and a ferroscan of that area for Owner’s Representative to review for potential expansion anchor drill locations.

E. Equipment Rough-In
   1. Rough-in locations shown on Mechanical Drawings for equipment furnished by Owner and for equipment furnished under other Divisions are approximate only. Obtain exact rough-in locations from following sources:
      a. From Shop Drawings for Contractor furnished and installed equipment.
      b. From Architect for Owner furnished-Contractor installed equipment.
      c. From existing equipment where such equipment is relocated under this Contract.
   2. Verify mechanical characteristics of equipment before starting rough-in. Where conflict exists between equipment and rough-in shown on Drawings obtain clarification from Architect and provide as directed at no increase in Contract Sum.
   3. Make final connections.

F. Concrete Pad
   1. Anchor equipment to concrete pad according to equipment manufacturer's written instructions and according to seismic codes at Project.
   2. Construct concrete pads of dimensions indicated, but not less than 4 inches (100 mm) high and extending 6 inches (150mm) beyond edge of the supported unit.
   3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.

4. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
8. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement.

G. Rooftop Equipment Supports
1. Provide leak proof equipment supports for all roof mounted equipment that does not come with an adequate curb and supports supplied.
2. Supports shall be prefabricated of continuous welded 18 gauge minimum galvanized steel, 12 inch minimum height, mitered corner seams, integral cant and base plate, 2 inch by 4 inch fire resistant treated wood nailer, or 18 gauge counter flashing. Provide integral internal reinforcing necessary to support imposed load, but no less than 600 pounds per linear foot of perimeter.
3. Top surface of equipment shall be level. Provide base or special curbs where installed on pitched roof.
4. Install all roof piping on supports, by Pate, Stiles or equal and approved.
5. Provide equipment support extension legs, galvanized and painted for use with pitch pockets.

H. Roof openings & curbs
1. All roof openings shall include sleeves and be finished with a watertight pre-fabricated roof curb.
2. Roof curbs shall be RPS, Pate Corp. or equal. Curbs shall have acrylic-coated ABS rib-reinforced plastic curb covers and EPDM protection rubber caps, complete with stainless steel snap-lock swivel clamps.
3. Counter flashing shall be required on curbed openings and shall be 16 ounce CRC, except where counter flashing is a component part of equipment. See Division 7 for details of flashing.

I. Grout
1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   a. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
2. Packaging: Premixed and factory packaged.
3. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
   a. Clean surfaces that will come into contact with grout.
   b. Provide forms as required for placement of grout.
   c. Avoid air entrapment during placement of grout.
   d. Place grout, completely filling equipment bases.
   e. Place grout on concrete bases and provide smooth bearing surface for equipment.
   f. Place grout around anchors.
   g. Cure placed grout.

J. Access Panels
   1. Place no valves, traps, controls, unions, dampers, coils, air distribution boxes, cleanouts, junction boxes, pull boxes, expansion joints, etc., in any system at a location that will be inaccessible after construction is completed. Maintain accessibility for all components in systems.
   2. Furnish all access doors required for all items located above finished ceilings, ceiling breaks or extensions behind finished walls or below finished floor, even though access doors may not be shown with the documents of this Division. Mark each door with a hidden identification tag cross-referenced to a plan location to ease installation by others.
   3. Furnish access door and panel types as specified under Section 08 31 13 - Access Doors and Frames, to ensure the same manufacturer for identical appearance and keying. Installation by Section 08 31 00 Contractor.
   4. Sizes: 12 by 12 inches for easily accessible items within 6 inches behind walls; 18 by 18 inches where partial body access is required; 24 by 24 inches at ceilings or where entire body access is necessary.

K. All work shall be performed by licensed contractors skilled in their respective trades.

3.8 START UP AND FIELD ADJUSTMENT

A. Startup Service:
   1. Prior to startup, ensure that systems are ready, including checking the following: Proper equipment rotation, proper wiring, auxiliary connections, lubrications, venting fan balance, controls and installed properly set relief and safety valves.
   2. Start and operate all systems. Provide services of factory trained technicians for startup of major equipment and systems including boilers, fire pumps, etc.

B. Contractor shall be responsible to change or adjust belts, drives, pulleys, motors, impellers, as required by balancing company to achieve the desired air and water delivery in an energy efficient manor by all air handling equipment, fans and pumps. Refer to Section 23 05 93.

3.9 OPERATION BY OWNER

A. Owner may require operation of parts or all of respective installations prior to final acceptance. Cost of utilities for such operation shall be paid by Owner.

B. Operation of installation shall not be construed as acceptance of Work.

3.10 TESTING

A. Labor, materials, instruments and power required for testing provided under respective Sections for Work under that Section. Test all systems as specified under various applicable Section. Duration of tests shall be determined by the authority having jurisdiction and in no case less than the time specified.

B. Test shall be performed to the satisfaction of the Owner's Representative and regulating authority having jurisdiction. Submit written certificates that tests have been performed in accordance with Specification requirements.

C. Repair or replace defective Work and repeat tests until particular systems, and component parts thereof, receive approval of Architect and regulating authority. Any damages resulting from tests shall be repaired and damaged material replaced, all satisfaction of Architect and at no cost to Owner.

D. Tests shall be performed on individual equipment, systems and their controls. Whenever the equipment or system under test is inter-related with, and depends upon, the operation of other equipment or systems and their controls for proper operation, functioning, and performance, the latter shall be operating simultaneously with equipment or system being tested.

E. Testing, adjusting and balancing of air and hydronic systems is specified under Section 23 05 93.

F. Pressure test piping before connection to equipment as required under Sections 23 21 13 and 23 22 13. No piping equipment or accessories shall be subjected to pressures exceeding their rating.

G. No piping shall be closed up, furred in, or covered before testing. Notify regulating authority and Owner's Representative with advanced notice as noted in Sections 23 21 13 and 23 22 13.

H. Drain water used for testing from the system after tests are complete. Repair or replace any damage caused by freezing of water left in system at no expense to the Owner.

I. Equipment and systems which normally operate during certain seasons of year shall be tested during the appropriate season.

J. After completion of testing and adjustment, operate the different systems and equipment under normal working conditions for 72 hours continuously and show specified performance. If, in the opinion of the Architect, performance of equipment or systems is not in accordance with specifications or submitted data, alter or replace equipment at no increase in Contract Sum. Contractor, at his opinion, may order tests from an independent approved laboratory to prove compliance. All such tests shall be at no increase in Contract Sum. Repeat process as often as required.

K. At completion of Work, provide written certification that all systems are functioning properly without defects.

3.11 PAINTING

A. All unpainted, non-insulated, non-galvanized, ferrous metal surfaces of pipes, equipment, fixtures, hangers, supports, and accessories painted under Section 09 90 00 - Painting and Coating.

B. Properly prepare Work under this Division to be finish painted under Section 09 90 00 - Painting and Coating.

C. Refinish Work supplied with final finish under this Division if damaged under this Division to satisfaction of Architect.

D. Provide moisture resistant paint for exterior painting and heat resisting paint for hot piping, equipment and materials.

E. Provide colors as directed by Architect unless specified otherwise.

F. Provide factory finishes as noted in the individual Equipment Sections.

G. For the following, provide factory prime coat.
   1. Air outlets: identified within relevant Section to be painted to match adjacent mounting surfaces.
   2. Access panels.

H. Paint all equipment out-of-doors and equipment supports with two coats of weather resistant enamel.

3.12 CLEANING

A. At all times keep the premises free from accumulation of waste material and debris caused by his employees. At the completion of the project, and at other times as Architect may direct, remove refuse from within and around the building. All tools, scaffolding and surplus materials shall also be removed, leaving the Site of his Work clean.

B. The Work of each Section includes removing tools, scaffolding, surplus materials, barricades, temporary walks, debris and rubbish from the Project promptly upon completion of that portion of the Work. Leave the area of operations completely clean and free of these items.

C. Clean premises of all excess construction material and debris caused by work, in accordance with Section 01 70 00.

D. During the course of construction, cap all ducts, pipe and electrical conduit in approved manner to ensure adequate protection against entrance of foreign substances.

E. Disconnect, clean and reconnect, whenever necessary, to locate and remove obstructions from any system. Repair or replace any Work damaged in the course of removing said obstructions at no additional cost to the Owner.

F. Clean ductwork inside and out before grilles are installed and before fans are operated.

G. Surfaces shall be left clean, debris shall be removed, and equipment shall be furnished in prime coat finish unless otherwise specified.

H. Clean exterior of piping, ductwork and equipment, exposed in complete structure. Remove rust, paint overspray, fireproofing overspray, plaster and dirt by wire brushing; remove grease, oil and similar materials by wiping with clean rags and suitable solvents.

I. Motors, Pumps, Air Moving Equipment and Other Items with Factory Finish: Remove grease, oil, paint overspray, fireproofing overspray, gypsum board mudsplatters and leave surfaces clean.

3.13 LUBRICATION

A. Lubricate all equipment at completion of Work. Furnish Owner with a written lubrication schedule for all equipment as specified in Section 01 78 00 - Closeout Submittals.

B. Extend grease fittings on all bearings to points of ready and easy accessibility.

C. Lubricate, as required, all motor and fan bearings, etc., before operation of any equipment.

D. Provide a final lubrication to all equipment requiring same immediately before turning over to Owner.

3.14 FINAL INSPECTION

A. The Contractor shall arrange for the all AHJ’s to make final inspections and correct all defects identified.

B. Prior to substantial completion the Contractor shall verify that the work is complete and that all incidental defects identified by the Architect/Engineer during construction have been corrected.

C. As the work nears completion, review the requirements of the Contract Documents, inspect the work and inform all parties involved in work to be corrected or completed before the project can be deemed substantially complete.

D. When the project is substantially complete, notify the Owner's Representative in writing of this fact, listing those items of work remaining incomplete, the reason for incompleteness, and the anticipated date that all remaining work will be completed. Carry out own final inspection and be satisfied that the work is complete. Final inspection of the project will then be scheduled by the Owner's Representative.

E. The Owner's Representative reserves the right to cancel and reschedule the inspection in the event considerable more work remains to be completed or corrected than indicated in the written request for inspection.

F. All items not completed or found not complying with drawings or specifications by the Owner's Representative will be identified in an inspection report by Owner's Representative.

G. Correct all items on inspection report. Make the correction and initial and date each item on the report after corrections have been completed.

H. Verify that all defective work has been corrected before offering the system for re-inspection.

3.15 PROJECT CLOSE-OUT

A. Prior to requesting Owner's Representative's inspection for certification of substantial completion, complete the following and list known exceptions in request:
   1. Obtain final inspections and approvals from all governmental jurisdictions that are required for the project.
   2. Submit record drawings, maintenance manuals, warranties, and similar final record information.
   3. Deliver tools, spare parts, extra stocks of materials, and similar physical items to the Owner.
   4. Complete start-up, testing and demonstration of systems to the satisfaction of the Owner's Representative that the entire installation is complete, properly adjusted and is in proper operating condition.
   5. Complete final cleaning requirements.
   6. Complete all training requirements for Owner’s Staff.
   7. Complete the Commissioning process.

End of Section

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Section 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors used for use with variable frequency drives shall be rated for inverter duty, and shall be furnished with AEGIS bearing protection rings. Acceptable Manufacturers shall be limited to Baldor, GE, Marathon.

C. Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

D. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Energy Code Requirements. NYSECCC C403.8.4 (Mandatory) motors 1/12 hp -3/4 hp shall be ECM or have a min motor efficiency of 70% with the means to adjust motor speed for balancing or remote control.

B. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

C. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

D. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

E. Motors 1/20 HP and Smaller: Shaded-pole type.

F. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

End of Section

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Section 23 05 16

EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Rubber packless expansion joints.
2. Grooved-joint expansion joints.
3. Alignment guides and anchors.
4. Pipe loops and swing connections.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

C. Rubber Packless Expansion Joints REJ-01:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Amber/Booth Company, Inc.; a VMC Group Company.
    b. Flex-Hose Co., Inc.
    c. Flexicraft Industries.
    d. Flex-Weld, Inc.
    e. Garlock Sealing Technologies.
    f. General Rubber Corporation.
    g. Mason Industries, Inc.
    h. Metraflex Company (The).
    i. Proco Products, Inc.
    j. Red Valve Company, Inc.
    k. Tozen Corporation.
    l. Unaflex.
    m. Unisource Manufacturing, Inc.
2. Standards: ASTM F1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
3. Material: Fabric-reinforced rubber complying with FSA-PSJ-703.
4. Arch Type: Single arches with external control rods.
5. Spherical Type: Single spheres with external control rods.
6. Minimum Pressure Rating for NPS 1-1/2 to NPS 4: 150 psig at 220 deg F.
7. Minimum Pressure Rating for NPS 5 and NPS 6: 140 psig at 200 deg F.
8. inimum Pressure Rating for NPS 8 to NPS 12: 140 psig at 180 deg F .
9. Material for Fluids Containing Acids, Alkalis, or Chemicals: Butyl rubber.
10. Material for Fluids Containing Gas, Hydrocarbons, or Oil: Buna-N.
11. Material for Water: Buna-N.
12. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.2 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides
1. Manufacturers: Subject to compliance with requirements, provide products by one of the:
a. Adsco Manufacturing LLC.
b. Advanced Thermal Systems, Inc.
c. Flexicraft Industries.
d. Hyspan Precision Products, Inc.
e. Metraflex, Inc.
f. Or Approved Equal.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A36/A36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
3. Washers: ASTM F844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

a. Stud: Threaded, zinc-coated carbon steel.
b. Expansion Plug: Zinc-coated steel.
c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install packed-type expansion joints with packing suitable for fluid service.

C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

D. Install rubber packless expansion joints according to FSA-PSJ-703.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

End of Section

Section 23 05 17

SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.

B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

C. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, anti-corrosion coated or zinc coated, with plain ends and integral welded waterstop collar.

D. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

E. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

F. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

G. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Smith, Jay R. Mfg. Co.
2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
3. Or Approved Equal.

B. Description: Manufactured, cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.
6. Or Approved Equal.

B. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20-psig
3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: [Stainless steel
5. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Presealed Systems.
2. Or Approved Equal.

B. Description:

1. Manufactured plastic, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.
2. Plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.6 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C920, Type S, Grade NS, Class 25, use NT.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. GE Construction Sealants; Momentive Performance Materials Inc.
b. Pecora Corporation.
c. Permathane®/Acryl-R®; ITW Polymers Sealants North America.
d. Polymeric Systems, Inc.
e. Sherwin-Williams Company (The).
f. The Dow Chemical Company.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. May National Associates, Inc.; a subsidiary of Sika Corporation.

C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Smooth-On.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

    a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls Above Grade:

    a. Piping Smaller Than NPS 6: Steel pipe sleeves.
    b. Piping NPS 6 and Larger: Steel pipe sleeves.

2. Exterior Concrete Walls Below Grade:

    a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal system.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs Above Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves.
b. Piping NPS 6 and Larger: Steel pipe sleeves.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: Steel pipe sleeves.
b. Piping NPS 6 and Larger: .

End of Section

Section 23 05 18

ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 DEFINITIONS

A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. BrassCraft Manufacturing Co.; a Masco company.
2. Dearborn Brass.
3. Jones Stephens Corp.
4. Keeney Manufacturing Company (The).
5. Mid-America Fittings, Inc.
6. ProFlo; a Ferguson Enterprises, Inc. brand.

2.2 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.

C. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.

E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
b. Chrome-Plated Piping: One-piece steel with polished, chrome-plated finish.
c. Insulated Piping: One-piece steel with polished, chrome-plated finish.
d. Insulated Piping: One-piece stainless steel with polished stainless-steel finish.
e. Insulated Piping: One-piece cast brass with polished, chrome-plated finish.
f. Insulated Piping: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
g. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
h. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
i. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.

j. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
k. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
l. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
m. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
n. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
o. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.
p. Bare Piping in Unfinished Service Spaces: One-piece cast brass with rough-brass finish.
q. Bare Piping in Unfinished Service Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
r. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.
s. Bare Piping in Equipment Rooms: One-piece cast brass with polished, chrome-plated finish.
t. Bare Piping in Equipment Rooms: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: Split floor plate.
2. Existing Piping to Remain: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

End of Section

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Section 23 05 19

METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Liquid-in-glass thermometers.
2. Thermowells.
3. Dial-type pressure gages.
4. Gage attachments.
5. Test plugs.
6. Test-plug kits.
7. Sight flow indicators.
8. Ultrasonic, thermal-energy meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

1.6 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN

REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Flo Fab Inc.
    b. Miljoco Corporation.
    c. Palmer Wahl Instrumentation Group.
    d. Tel-Tru Manufacturing Company.
    e. Trerice, H. O. Co.
    f. Weiss Instruments, Inc.
    g. Winters Instruments - U.S.
    h. Or Approved Equal.

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or acrylic.
8. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Ernst Flow Industries.
    b. Marsh Bellofram.
    c. Miljoco Corporation.
    d. Palmer Wahl Instrumentation Group.
    e. REOTEMP Instrument Corporation.
    f. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
    g. Weiss Instruments, Inc.

h. WIKA Instrument Corporation - USA.
i. Or Approved Equal.

2. Standard: ASME B40.200.
3. Case: Plastic; 9-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or acrylic.
8. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.3 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Type: Stepped shank unless straight or tapered shank is indicated.
4. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
5. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
6. Bore: Diameter required to match thermometer bulb or stem.
7. Insertion Length: Length required to match thermometer bulb or stem.
8. Lagging Extension: Include on thermowells for insulated piping and tubing.
9. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
10. Thermowell length shall be in accordance with ISA standards and shall include the appropriate extension to allow for pipe installation. Extension neck shall be included when required to match thermowell and insulation thickness.
11. Material: All steam pipes to be stainless steel.
12. Material: All water services to be brass steel.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.4 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. AMETEK, Inc.; U.S. Gauge.
   b. Ashcroft Inc.
   c. Ernst Flow Industries.
   d. Flo Fab Inc.
   e. Marsh Bellofram.
   f. Miljoco Corporation.
   g. Noshok.
   h. Palmer Wahl Instrumentation Group.
   i. REOTEMP Instrument Corporation.
   j. Tel-Tru Manufacturing Company.
   k. Trerice, H. O. Co.
   l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   m. Weiss Instruments, Inc.
   n. WIKA Instrument Corporation - USA.
   o. Winters Instruments - U.S.
   p. Or Approved Equal.

2. Standard: ASME B40.100.
3. Pressure gauges: stainless steel case, non-repairable, silicone filled with minimum 3 1/2" diameter case. Gauges shall have 3% accuracy over the appropriate range of 0-30 psi, 0-100, or 0-160; and shall include a shut-off ball valve (gauge cocks are not permitted). Include a pigtail cooling loop on all steam gauges. Scale should be selected to provide a reading at mid-scale during normal operation. No snubbers are allowed.

2.5 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Flow Design, Inc.
2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.
9. Or Approved Equal.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Pressure/temperature test ports shall be provided on each coil bank, heat exchanger, fan coil, and at all permanent pressure gauge locations. Use extended body style to allow for insulation thickness.

G. Seals shall be appropriate for operating water temperature and pressure as follows:
1. Hot Water, Glycol = Nordel (EPDM)
2. Cold Water, Chilled Water = Neoprene

2.6 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Flow Design, Inc.
2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.
9. Or Approved Equal.

B. Furnish 2 test-plug kit(s) containing one low-range thermometer, one high range thermometer, one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig.

F. Carrying Case: Metal or plastic, with formed instrument padding.

2.7 SIGHT FLOW INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Archon Industries, Inc.
2. Dwyer Instruments, Inc.
3. Emerson Process Management; Brooks Instrument.
4. Ernst Co., John C., Inc.
5. Ernst Flow Industries.
6. KOBOLD Instruments, Inc. - USA; KOBOLD Messring GmbH.
7. OPW Engineered Systems; a Dover company.
8. Penberthy; A Brand of Tyco Valves & Controls - Prophetstown.
9. Or Approved Equal.

B. Description: Piping inline-installation device for visual verification of flow.

C. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.

D. Minimum Pressure Rating: 125 psig.

E. Minimum Temperature Rating: 200 deg F.

F. End Connections for NPS 2 and Smaller: Threaded.

G. End Connections for NPS 2-1/2 and Larger: Flanged.

2.8 THERMAL-ENERGY METERS

A. For buildings supplied by steam, the meter shall measure the condensate return flow; for hot water systems, the district hot water supply shall be metered. In either case, the meter shall be sized and provided by Cornell for installation by the Contractor.

B. Meter will be vortex shedding design. Expect a 1-inch NPS pipe size, which handles flows from 3 – 70 gpm. Meters will have eight digit local totaling displays (gallons) and a one pulse per gallon, 5 volt pulse output. Output shall be tied to the building BACS. Meters shall have internal line voltage power supply.

C. Meters shall be located in a readable location, three to five feet off finished floor.

D. Condensate meters shall be installed downstream of a vented condensate receiver as indicated on Standard Detail 3.2.2 – Condensate Receiver and Meter.

E. Post metering run piping shall incorporate a spring loaded, self-seated check valve to prevent backflow leakage.

F. Condensate pump discharge piping shall contain anti-siphon elements.

G. Allow for 24-inches of straight 1-inch pipe upstream of the meter; and 12-inches of straight 1-inch pipe downstream of the meter.

H. Meters shall be valved to allow verification of check valve leakage and to allow calibration using a 32 gallon trash can.

I. Meters are noise sensitive. Meters shall be located as far from nearest line pump as possible.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

H. Install valve and snubber in piping for each pressure gage for fluids.

I. Install test plugs in piping tees.

J. Install flow indicators in piping systems in accessible positions for easy viewing.

K. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

L. Install flowmeter elements in accessible positions in piping systems.

M. Install wafer-orifice flowmeter elements between pipe flanges.

N. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

O. Install permanent indicators on walls or brackets in accessible and readable positions.

P. Install connection fittings in accessible locations for attachment to portable indicators.

Q. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

R. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic coil in air-handling units.
3. Two inlets and two outlets of each hydronic heat exchanger.
4. Inlet and outlet of each thermal-storage tank.
5. Outside-, return-, supply-, and mixed-air ducts.

S. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Suction and discharge of each pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic zone shall be each of the following:
1. Industrial-style, liquid-in-glass type.

2. Test plug with EPDM self-sealing rubber inserts.

B. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be each of the following:
   1. Industrial-style, liquid-in-glass type.
   2. Test plug with EPDM self-sealing rubber inserts.

C. Thermometers at inlets and outlets of each hydronic heat exchanger shall be each of the following:
   1. Industrial-style, liquid-in-glass type.
   2. Test plug with EPDM self-sealing rubber inserts.

D. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be the following:
   1. Industrial-style, liquid-in-glass type.

E. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.

B. Scale Range for Condenser-Water Piping: 0 to 120 deg F.

C. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F.

D. Scale Range for Air Ducts: 0 to 100 deg F.

E. Range selected such that normal working reading is approximately in the 1/3 center of meter range.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be one of the following:

   1. Sealed, direct-mounted, metal case.
   2. Test plug with EPDM self-sealing rubber inserts.

B. Pressure gages at suction and discharge of each pump shall be one of the following:

   1. Sealed, direct-mounted, metal case.
   2. Test plug with EPDM self-sealing rubber inserts.

C. On devices such as pumps, strainers, coils, etc., where the differential pressure is the desired information, install only one pressure gauge with valved connections to the upstream and downstream pressure taps. Include a P/T test port in addition to the pressure gauge. Provide a second set of isolating valves at the gauge if gauge location is not within reach of tap points.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 160 psi.

B. Scale Range for Condenser-Water Piping: 0 to 160 psi.

C. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi.

D. Range selected such that normal working reading is approximately in the 1/3 center of meter range.

3.8 THERMAL-ENERGY METER SCHEDULE

A. Thermal-Energy Meters for Chilled-Water Piping: Ultrasonic type.

B. Thermal-Energy Meters for Condenser-Water Piping: Ultrasonic type.

C. Thermal-Energy Meters for Heating, Hot-Water Piping: Ultrasonic type.

End of Section

Section 23 05 23

GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Ball valves.
2. Gate valves.
3. Globe valves.
4. Butterfly valves.
5. High-performance butterfly valves.
6. Check valves.
7. Calibrated balancing valves.
8. Pressure and safety relief valves.
9. Air vents.
10. Drain valves.
11. Chainwheel actuators.

B. Related Sections:

1. Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve indicated.

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

C. To assure uniformity and compatibility, all grooved end valves and adjoining couplings shall be the products of a single manufacturer

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

1.7 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 and larger.

2. Handwheel: For valves other than quarter-turn types.

3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.

4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.

5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.

2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.

2. Solder Joint: With sockets according to ASME B16.18.

3. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE BALL VALVES

A. Two-Piece Bronze Ball Valves with Regular Port and Stainless-Steel Trim:

1. For ALL water services, low pressure steam, low pressure condensate service:

2. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Apollo: 70-140, 70-240
   b. Nibco: T-580-70-66, S-580-70-66
   c. Watts: B6000-SS, B6001-SS

3. Description:

   a. Bronze Body; Standard Port; Two-Piece; 316 Stainless Steel Ball and Stem; Reinforced teflon (RTFE) seat, 15% glass filled double seal; Seat working P/T rating 300 psig @ 250 ˚F minimum; Body working P/T rating 300 psig @ 300 ˚F minimum; WOG rating 300 psig minimum; saturated steam rating 150 psig minimum; Lever Handle Actuator.

2.3 STEEL BALL VALVES

A. Steel Ball Valves:

1. For High Pressure Steam and Condensate Service

2. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Metso Jamesbury: Series 4000
   b. SVF Flow Controls: Series N8
      JFlow Controls: Series 4600

3. Description:

   a. ASTM A216 WCB Cast Steel or ASTM A351 CF8M 316 stainless steel body; Standard Port; Three-Piece; 4-bolt clamp; butt or socket weld connection; 316 Stainless Steel Ball and stem; High temperature RTFE double seal; seat working P/T rating 100 psig @ 450 ˚F minimum; body working P/T rating 750 psig @ 100 ˚F minimum; WOG rating 400 psig minimum; steam rating 100 psig @ 450 ˚F minimum; lever handle actuator.

2.4 BRONZE GLOBE VALVES (Use only for bypass service)

A. Class 125 Bronze Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Apollo Valves
    b. Crane; Crane Energy Flow Solutions
    c. Hammond Valve
    d. KITZ Corporation
    e. NIBCO Inc.
    f. Milwaukee Valve Company
    g. Watts; a Watts Water Technologies company
    h. Or approved equal

2. Description:

    a. Standard: MSS SP-80, Type 1.
    b. CWP Rating: 200 psig (1380 kPa).
    c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
    d. Ends: Threaded or solder joint.
    e. Stem and Disc: PTFE.
    f. Packing: Asbestos free.
    g. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 150 Bronze Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Apollo Valves
    b. Crane; Crane Energy Flow Solutions
    c. Hammond Valve
    d. KITZ Corporation
    e. NIBCO Inc.
    f. Milwaukee Valve Company
    g. Watts; a Watts Water Technologies company
    h. Or approved equal

2. Description:

    a. Standard: MSS SP-80, Type 2.
    b. CWP Rating: 300 psig (2070 kPa).
    c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
    d. Ends: Threaded.
    e. Stem: Bronze.
    f. Disc: PTFE.
    g. Packing: Asbestos free.
    h. Handwheel: Malleable iron, bronze, or aluminum.

2.5 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves:

1. For ALL water services

2. Manufacturers: Acceptable manufacturers are as follows:

a. Keystone: Series 60
b. Nibco: LD-3022
c. Watts: BF-03

3. Description:

~~a.~~ Ductile or Cast iron body; fully lugged; 316 or 17-4 pH stainless steel trim; stainless steel disc; resilient seat fully bi-directional dead-endable; EPDM seat; seat working P/T rating 150 psig @ 250 ˚F minimum; body working P/T rating ANSI 150; under 4"- locking lever Handle; over 4" handwheel gear operator.

2.6 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:

1. For Chilled water building entrance service

2. Manufacturers: Acceptable manufacturers are as follows:

a. Keystone: K-LOK F362
b. Jamesbury: 815L
c. Tri-Seal Contromatics: QF-1151

3. Description:

a. Ductile Iron or Carbon Steel body tapped lug full flange; 316 stainless steel double offset stem; 316 stainless steel disc; PTFE fully bi-directional dead-endable seat; seat working P/T rating 100 psig @ 375 ˚F minimum; body working P/T rating ANSI 150; under 4"- locking lever Handle; over 4" handwheel gear operator.

B. Class 150, Single-Flange, High-Performance Butterfly Valves:

1. For High pressure steam and condensate

2. Manufacturers: Acceptable manufacturers are as follows

a. Adams: MAK
b. Miller: Quadax
c. Pentair Vannessa: Series 30,000
d. Weir: Tricentric

e. Zwick Tri-Con: Model I1

3. Description:

a. High Performance, Triple Offset Design for high pressure steam and condensate: ASTM A216 WCB carbon steel body; double flanged, ISO 5272 short pattern; stainless steel trim; ASTM A351 CF8M or 316 stainless steel disc; fully bi-directional dead-endable; stainless steel seal; graphite shaft packing; seat working P/T rating 100 psig @ 450 ˚F minimum; body working P/T rating ANSI 150; handwheel gear operator.

C. Class 150, Single Flange, High-Performance Butterfly Valves:

1. For low pressure steam and condensate

2. Manufacturers: Acceptable manufacturers are as follows

a. Keystone: K-LOK F362
b. Jamesbury: 815L
c. Tri-Seal Contromatics: QF-1151

3. Description:

High Performance, Double Offset Design for low pressure steam and condensate: ASTM A216 WCB carbon steel body; single flange lugged; 316 stainless steel double offset stem; 316 stainless steel disc; RPTFE fully bi-directional dead-endable seat; seat working P/T rating 100 psig @ 450 ˚F minimum; body working P/T rating ANSI 150; handwheel gear operator.

2.7 CHECK VALVES

A. Two inches (2") and under: 45˚ swing check, screwed end.

B. Two and one half inches (2-1/2") and over: Non-slam type globe style lift check, non-slam type tilting disc or wafer body non-slam type lift check. Double disc or bi-folding disc type valves are not acceptable.

2.8 IRON GLOBE VALVES (Use only for bypass service)

A. Class 125, Iron Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Crane Co.; Crane Valve Group; Stockham Division.
b. Milwaukee Valve Company.
c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
d. Or Approved Equal.

2. Description:

   a. Standard: MSS SP-85, Type I.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Packing and Gasket: Asbestos free.

B. Class 250, Iron Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Crane Co.; Crane Valve Group; Stockham Division.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. Or Approved Equal.

2. Description:

   a. Standard: MSS SP-85, Type I.
   b. CWP Rating: 500 psig.
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Packing and Gasket: Asbestos free.

2.9 DRAIN VALVES

A. Manufacturers:

1. NIBCO, Inc.
2. Crane Valve, North America.
3. Red Valve Company.
4. Or approved equal

B. 3/4 inch, MSS SP 110, 600 psi WOG, two piece bronze body, chrome plated brass ball, full port, Teflon seats, blow-out proof stem, solder or threaded ends, lever handle, hose cap and chain. Provide stem extension for insulated applications.

2.10 CALIBRATED BALANCING VALVES

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. TA Hydronics.
2. Bell & Gossett.
3. Or approved equal.

B. Up to 2 Inches: Nonferrous, pressure die cast, nonporous copper alloy body. EPDM seat and probe seals. TA Hydronics Series 786 or 787, or equal.

C. Over 2 Inches: Ductile Iron body conforming to ASTM Grade A535. All other metal parts shall be of nonferrous copper alloy. EPDM seat and probe seals. TA Hydronics Series 788, or equal.

D. All balancing valves shall include a concealed memory with a locking tamperproof setting.

E. All balancing valves shall be furnished with valve manufacturer's preformed rigid polyurethane thermal insulation and extended level stem.

F. All balancing valves shall appropriate for system pressure class installed.

2.11 PRESSURE AND SAFETY RELIEF VALVES

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Watts.
2. Consolidated.
3. Kunkle.
4. Manufacturer of equipment requiring the safety relief valve.
5. Or approved equal.

B. Valve: Bronze body, Teflon seat, stainless steel valve spring, and trim, automatic direct pressure actuated, capacities ASME certified and labeled.

C. Type and size as applicable, constructed and rated in accordance with ASME, and so stamped.

D. Piped to safe location outdoors.

E. Use "pressure relief valves" for unheated liquids.

F. Use "safety relief valves" for heated liquids.

G. Valves suitable and rated for proper temperatures; for "safety relief valves" minimum temperature rating is saturated steam temperature corresponding to pressure 10 percent higher than valve set pressure.

H. Valves shall have set pressure indicated but not more than working pressure of protected equipment.

I. Valves shall open, under test, at set pressure, with tolerance of plus or minus 2 psi for set pressures up to 70 psig, and plus or minus 3 percent for set pressures in excess of 70 psig.

J. Valves shall have capacity to relieve maximum possible generated energy while maintaining pressure in protected equipment at no more than 10 percent above vessel working pressure.

K. Provide multiple valves if required for capacity even though only one valve may be shown on Drawings.

2.12 BALL VALVES, HIGH PRESSURE STEAM AND CONDENSATE

A. A. For high pressure steam, trap station, and condensate service, ball valves shall be as follows:

1. Body: ASTM A216 WCB Cast Steel or ASTM A351 CF8M 316 Stainless Steel
2. Body Style: Standard Port, Three-Piece, 4-bolt clamp Butt or socket weld connection
3. Trim: 316 Stainless Steel Ball and Stem
4. Seat: High Temperature RTFE, double seal
5. Seat Working P/T Rating: 100 psig @ 450˚F Minimum
6. Body Working P/T Rating: 750 psig @ 100˚F Minimum
7. WOG Rating: 400 psig Minimum
8. Steam Rating: 100 psig @ 450˚F Minimum
9. Actuator: Lever Handle

Use carbon steel bodies when connecting to carbon steel piping systems, which are generally located within the building perimeter. Use stainless steel bodies when connecting to stainless steel piping systems, which are generally located outside the building perimeter.

B. Acceptable Models, Valve Type V-3:
1. Metso Jamesbury: Series 4000
2. SVF Flow Controls: Series N8
3. JFlow Controls: Series 4600

2.13 AIR VENTS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Bell and Gossett.
2. Taco.
3. Hoffman.
4. Armstrong.

5. Or approved equal.

B. Manual Type: 3 inch tall vertical sections of 2 inch diameter pipe to form air chamber, with 1/4 inch ball valve at top of chamber with hose bibb and cap.

C. No automatic air vents to be used on the project.

2.14 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.
4. Or Approved Equal.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.

2. Attachment: For connection to ball, butterfly valve stems.

3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.

4. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Provide all equipment with shutoff valves. Provide all valves, strainers and check valves, except control valves and unless specifically sized, of same size as the pipes in which they are installed unless otherwise indicated. Provide fixture stops.

C. Provide shut-off valves for shut-off at each riser connection.

D. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

E. All hand-controlled line valves are to be gate, ball or butterfly valves, except where throttling control or frequent operation is required, provide globe, butterfly or angle valves, unless otherwise shown or specified. Install all globe and angle valves to close against system pressure.

F. Position gate valves so that stems are in any suitable angle from horizontal to upright position, not inverted. Install valves only in accessible locations. Provide access doors where valves and fittings are not accessible. Coordinate size and location of access doors with Section 08 31 13.

G. Wherever possible, install valves accessible from floor level or maintenance platform. Provide guided chain operators on valves over 8 feet above floor or maintenance platform in equipment areas. Extend chains to within 6 feet off floor. Provide operating handles for all valves and cocks without integral operators. Provide adequate clearance for easy operation. Install valves in position to allow full stem movement.

H. Support line valves at the valve in addition to regularly spaced pipe supports shown and specified.

I. Provide extended level handle to accommodate insulation.

J. Provide ball blow-down valves and hose adaptors at strainers, air separators, tanks, pipe traps, equipment drains, etc. of same size as strainer blow-off connection.

K. Install 3/4 inch (20 mm) ball valves with cap for drains at main shut-off valves, low points of piping, and at equipment. Provide 2 inch (50 mm) ball valve with cap at bases of vertical risers. When located above ceilings, locate drain valves 6 inches from access panels for fixed ceilings and 6 inches above ceiling for accessible ceilings.

L. Provide relief valves on pressure tanks, low-pressure side of reducing valves, heat exchangers, and expansion tanks.

M. Select system relief valve capacity greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

N. Pipe relief valve outlet to nearest floor drain.

O. Provide discharge pipe to atmosphere from all relief and safety valves, sized with area equal to sum of outlet areas of all valves connected thereto, unless indicated larger. Extend to over approved drain receptacle with airgap.

P. Provide ball valves to isolate expansion devices.

Q. Provide open-ended line valves with plugs or blind flanges.

R. Provide valves at points shown and as required for complete isolation of equipment, risers, branches off mains, automatic valves and tanks arranged so as to give complete and regulation control of piping systems throughout the building. Install valves, with neat appearance and grouping, so that all parts are easily accessible for maintenance. Not all isolation valves are indicated on drawings.

S. Provide isolation valves at automatic bypass valves and low flow bypass valves Install valves, with neat appearance and grouping, so that all parts are easily accessible for maintenance. Not all isolation valves are indicated on drawings.

T. Install check valves for proper direction of flow and per manufacturer's directions.

U. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

V. Locate valves for easy access and provide separate support where necessary.

W. Install valves in horizontal piping with stem at or above center of pipe.

X. Install valves in position to allow full stem movement.

Y. Install chainwheels on operators for butterfly, gate, globe valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

Z. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Lift Check Valves: With stem upright and plumb.

3.3 TESTING

A. Test valve bonnets for tightness. Operate valves from closed-to-open-to-closed position while valve is under test pressure.

A. Test automatic valves including solenoid valves, expansion valves, water regulating valves, pressure reducing valves, pressure relief valves, safety valves and temperature and pressure relief valves for proper operation at settings indicated.

B. Insure that valves are field checked for packing and lubricant and that disc is for service intended. Replace leaking packing. Service valves which do not operate smoothly and properly with suitable lubricant before placing in operation.

C. Test relief valves, safety relief valves, safety valves and temperature and pressure relief valves three times.

3.4 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.5 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.

2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.

3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.

4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.

6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

7. For Grooved-End Copper Tubing and Steel Piping, except for Steam and Steam Condensate Piping: Valve ends may be grooved.

C. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball, butterfly valves.

2. Butterfly Valve Dead-End Service: Single-flange (lug) type.

3. Throttling Service except Steam: Globe, ball, or butterfly valves.

4. Throttling Service, Steam: Globe valves.

D. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.

2. For Steel Piping, NPS 2 and Smaller: Threaded ends.

3. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.

4. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.6 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Two piece, standard port, bronze ball valve with stainless steel trim.

1. Valves may be provided with solder-joint ends instead of threaded ends.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron globe valves (by pass only) , Class 125, Class 250 with flanged ends.

C. Pipe NPS 2-1/2 (DN 65) and Larger:

1. General Chilled Water Service: Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM seat, aluminum-bronze disc.

2. Chilled Water Building Service Entrance: High-Performance Butterfly Valves: Class 150, double offset, 375F temperature rating.

D. Pipe NPS 2 (DN 50) and Smaller Check:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.

E. Pipe NPS 2-1/2 (DN 65) and Larger Check:

1. Iron Swing Check Valves: Class 125, Class 250, metal seats.

2. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and spring.

3. Iron, Grooved-End Check Valves, NPS 3 to NPS 12 (DN 80 to DN 300): 300 CWP.

3.7 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Two piece, standard port, bronze ball valve with stainless steel trim.

1. Valves may be provided with solder-joint ends instead of threaded ends.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron globe valves, Class 125, Class 250 with flanged ends.

C. Pipe NPS 2-1/2 (DN 65) and Larger:

1. General Heating Water Service: Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM seat, aluminum-bronze disc.
2. High-Performance Butterfly Valves: Class 150, Class 300, single flange.

3.8 HIGH PRESSURE STEAM AND CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Three-piece, standard port, steel ball valves

B. Pipe NPS 2-1/2 (DN 65) and Larger: Class 150 high performance butterfly valve, triple offset, 450F temperature rating

3.9 LOW PRESSURE STEAM AND CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Two-Piece, standard port, bronze ball valve with stainless steel trim

B. Pipe NPS 2-1/2 (DN 65) and Larger: Class 150 High Performance Butterfly Valve, double offset, 450F temperature rating

3.10 AIR VENT AND DRAIN VALVE APPLICATION

Equipment type	**Required locations**	**Comments**
Manual air vents	On chilled water and glycol service use manual vents only On each side of each heat-transfer device Each high point in the piping system on the floor layout	Provided threaded hose end connection
Manual drain valves	Bottoms of risers	Size for ¾” with threaded hose end connection. Coordinate with plumbing for nearby approved receptor drain.
Manual drain valves	On each side of each heat-transfer device Each low point in the piping system on the floor layout At each mains shut-off	Provided threaded hose end connection

End of Section

Section 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Fastener systems.
5. Pipe stands.
6. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
3. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration isolation devices.
4. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

D. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. ABB (Electrification Products Division).
   b. Atkore International (Unistrut).
   c. Eaton (B-line).
   d. Flex-Strut Inc.
   e. G-Strut.
   f. Haydon Corporation.
   g. MIRO Industries.
   h. Wesanco, Inc.

2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted carbon-steel channel with inturned lips.
5. Channel Width: Selected for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
8. Metallic Coating: Hot-dip galvanized.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Hilti, Inc.
b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
c. MKT Fastening, LLC.
d. Simpson Strong-Tie Co., Inc.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (B-line).
b. Empire Tool and Manufacturing Co., Inc.
c. Hilti, Inc.
d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
e. MKT Fastening, LLC.

2. Indoor Applications: stainless-steel.
3. Outdoor Applications: Stainless steel.

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand:

1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Hardware: Galvanized steel or polycarbonate.
4. Accessories: Protection pads.

C. Low-Profile, Single Base, Single-Pipe Stand:

1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Vertical Members: Two, galvanized-steel, continuous-thread 1/2-inch (12-mm) rods.

4. Horizontal Member: Adjustable horizontal, galvanized-steel pipe support channels.
5. Pipe Supports: Roller.
6. Hardware: Galvanized steel.
7. Accessories: Protection pads.
8. Height: 12 inches above roof.

D. High-Profile, Single Base, Single-Pipe Stand:

1. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Single vulcanized rubber or molded polypropylene.
3. Vertical Members: Two, galvanized-steel, continuous-thread 1/2-inch (12-mm) rods.
4. Horizontal Member: One, adjustable height, galvanized--steel pipe support slotted channel or plate.
5. Pipe Supports: Roller.
6. Hardware: Galvanized steel.
7. Accessories: Protection pads, 1/2-inch continuous-thread galvanized-steel rod.
8. Height: 36 inches above roof.

E. High-Profile, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: Two or more; vulcanized rubber.
3. Vertical Members: Two or more, galvanized-steel channels.
4. Horizontal Members: One or more, adjustable height, galvanized-steel pipe support.
5. Pipe Supports: Roller.
6. Hardware: Galvanized steel.
7. Accessories: Protection pads, 1/2-inch continuous-thread rod.
8. Height: 36 inches above roof.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

F. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Isolate all pipes attached to the inlet and discharge of spring-isolated equipment and pressure-reducing valves using the same isolator type and static deflection as the equipment isolators within the mechanical room or 50 feet (whichever is greater) from the inlet and discharge.

B. Isolate the remainder of horizontal pipe runs 2-in in diameter and greater using Type NM or NH isolators.

C. All vertical risers for piping 2-in diameter or greater shall be isolated from the building structure by means of guides, supports, and spring isolators. The support systems shall be an engineered solution taking into account pipe movement, expansion and vibration isolation.

D. All vertical risers for piping less than 2-in diameter shall be isolated from the building structure by Type NM neoprene mount below flanges or pipe clamps. Where fixing to structure is required, neoprene isolator bushings shall be used to provide resilient support.

E. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

F. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

G. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.

H. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.

I. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

J. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

K. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

L. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

M. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

N. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

O. Install lateral bracing with pipe hangers and supports to prevent swaying.

P. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts

before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

Q. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

R. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

S. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
    b. NPS 4: 12 inches long and 0.06 inch thick.
    c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
    d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
    e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.

6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

End of Section

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Section 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Freestanding and restrained spring isolators.
4. Housed spring mounts.
5. Elastomeric hangers.
6. Spring hangers.
7. Spring hangers with vertical-limit stops.
8. Pipe riser resilient supports.
9. Resilient pipe guides.
10. Restraining braces and cables.
11. Steel and inertia, vibration isolation equipment bases.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
4. Seismic Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
    c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
    d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.

E. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.8 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Isolation Technology, Inc.

5. Kinetics Noise Control.
6. Mason Industries.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.
10. Or approved equal

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Restrained Mounts: All-directional mountings with seismic restraint.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
2. Base: Factory drilled for bolting to structure.
3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch–travel up or down before contacting a resilient collar.

H. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

I. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

J. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

L. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 VIBRATION ISOLATION EQUIPMENT BASES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Isolation Technology, Inc.
4. Kinetics Noise Control.
5. Mason Industries.
6. Vibration Eliminator Co., Inc.
7. Vibration Isolation.
8. Vibration Mountings & Controls, Inc.
9. Or Approved Equal.

D. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

E. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

   a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.3 SEISMIC-RESTRAINT DEVICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti, Inc.
5. Kinetics Noise Control.
6. Loos & Co.; Cableware Division.
7. Mason Industries.
8. TOLCO Incorporated; a brand of NIBCO INC.
9. Unistrut; Tyco International, Ltd.
10. Or Approved Equal.

D. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

E. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch thick resilient cushion.

F. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

G. Restraint Cables: ASTM A 603 galvanized-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

H. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

I. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

J. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

K. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

L. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

M. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.4 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

C. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

D. Install cables so they do not bend across edges of adjacent equipment or building structure.

E. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach

equipment. Comply with requirements in Section 232113 "Hydronic Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
10. Air-Mounting System Operational Test: Test the compressed-air leveling system.
11. Test and adjust air-mounting system controls and safeties.
12. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

E. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Section 017900 "Demonstration and Training."

End of Section

Section 23 05 53

IDENTIFICATION FOR HVAC DUCTWORK, PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

1.5 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11 inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Red.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger

lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: Fiberboard or metal.
2. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior in colors according to ASME A13.1 unless otherwise indicated.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.

2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Section 099123 "Interior Painting"

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:

1. Chilled-Water Piping:

   a. Background Color: Blue.
   b. Letter Color: White.

2. Condensate Drain Piping:

a. Background Color: Yellow.
b. Letter Color: Black.

3. Heating Water Piping:

a. Background Color: Yellow.
b. Letter Color: Black.

4. Steam and Condensate Piping:

a. Background Color: Yellow.
b. Letter Color: Black.

5. Refrigerant Piping:

a. Background Color: Red.
b. Letter Color: White.

6. Fuel Oil Piping:

a. Background Color: Black.
b. Letter Color: White.

D. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For supply ducts.
2. Yellow: For outside air ducts.
3. Green: For exhaust-, relief-, return- air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

E. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch–high is needed for proper identification because of distance from normal location of required identification.

F. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 25 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape: round

2. Valve-Tag Color: Natural

3. Letter Color: Black

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

End of Section

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Section 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:
    a. Constant-volume air systems.
    b. Variable-air-volume systems.
2. Balancing Hydronic Piping Systems:
    a. Hydronic systems.
    b. Primary-secondary hydronic systems.
3. Balancing steam systems.
4. Testing, Adjusting, and Balancing Equipment:
    a. Heat exchangers.
    b. Motors.
    c. Condensing units.
    d. Heat-transfer coils.
5. Testing, adjusting, and balancing existing systems and equipment.
6. Sound tests.
7. Vibration tests.
8. Duct leakage tests.
9. Control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: If requested by the Owner, conduct a TAB conference at a facilitiers approved location at the Cornell campus after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.5 ACTION SUBMITTALS

A. Sustainable Design Submittals:

1. Air-Balance Report: Documentation indicating that Work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
2. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

3. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 60 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 60 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. System Readiness Checklists: Within 60 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.7 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.

B. TAB Specialists Qualifications: Certified by NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB as a TAB technician.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.8 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. Subject to compliance with requirements, [**engage one of the following**] [**available TAB specialists that may be engaged include, but are not limited to, the following**]:

1. <**Confirm with Cornell>**

3.2 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning per the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in ASHRAE 111 and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

M. Calibration of air flow measurement stations in cooperation and in conjunction with ATC contractor, provide all necessary pitot tube traverses and/or other air measurements necessary to field verify the accuracy of all installed air flow measurement stations at all air handling units, exhaust air handling units, return fans and cuts. Calibration readings shall be taken at 100%, 75%, 50% of rated flow and a curve shall be prepared that indicates any deviation between air flow station readings and field readings at these floors.

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses, close to the fan and prior to any outlets, to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

2. AHU Pressure Profile
    a. Measure static pressure across each component that makes up an air handling unit, rooftop unit, and other air handling and treating equipment.
        1) Note condition of all filters, position of all dampers, and all airflow values (OA/RA/SA/EA) at the time of measurement.

3. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.

c. Measure static pressure across each component that makes up the air-handling system.
d. Report artificial loading of filters at the time static pressures are measured.

4. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
5. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.
4. Record final positions for each submain and branch volume damper.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.
5. Record final positions for each final volume damper.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, CFM, VFD speed, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Record all operating data, rpms, volts, amps, CFM, VFD speed, and static profile.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of

the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Determining new maximum static pressure setpoint:
   1. Once the proper airflow diversity rate has been achieved, the duct static pressure setpoint shall be incrementally reduced until the furthest open damper reaches 100% open. The drive speed, pressure setpoint and full open terminal unit shall be noted on the pre-balance report.
   2. Once a single terminal unit reaches 100% open, the duct static pressure setpoint shall continue to be incrementally reduced until the second furthest open damper reaches 100% open. The drive speed, pressure setpoint and full open terminal unit shall be noted on the pre-balance report.

C. Balance the terminal units variable-air-volume systems as follows:

   1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
   2. Verify that the system is under static pressure control.Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

      a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
      b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
         1) Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
         2) Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable. Note damper position required at terminal unit to achieve design airflow at final static pressure.
      c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
         1) Balance air outlets with the minimum possible total pressure drop. Each system should have one air path with fully open balancing dampers downstream of the air terminal unit.
         2) Record the manual balancing damper position of each volume damper.
      d. Adjust controls so that terminal is calling for minimum airflow.
      e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
      f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
      g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
      h. If the total available air is above or below design and cannot be decreased or increased, the air distribution system shall be proportionally balanced to within 10% of the available total. Deficiencies shall be noted in the TAB Report Summary.

3. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
    c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    e. Conduct 3-point calibration of all airflow stations within the air handling unit as outlined in the general procedures for balancing air systems.
    f. Record total airflow from the sum of the terminal units as reference to measured total airflow from pitot/coil traverse. Both must be recorded on the final report.

4. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report any artificial loading of filters at the time static pressures are measured.

5. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
    b. Verify that terminal units are meeting design airflow under system maximum flow.

6. With the terminal units calibrated and volume dampers at the correct postion, repeat the procedure for determining maximum static pressure setpoint.
7. Verify final system conditions as follows:

    a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
    b. Re-measure and confirm that total airflow is within design.
    c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
    d. Mark final settings.
    e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
    f. Verify tracking between supply and return fans.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

D. Calibration of water flow measurement stations in cooperation and in conjunction with ATC contractor, provide all necessary flow meters and other devices to provide measurements necessary to field verify the accuracy of all installed water flow measurement stations. Calibration readings shall be taken at 100%, 75%, 50% of rated flow and a curve shall be prepared that indicates any deviation between water flow station readings and field readings at these floors.

3.9 PROCEDURES FOR HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity:

1. Adjust pumps to deliver total design gpm.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed. Verify flow rate from measured meter with a clamp on-type flow meter. Provide both values on final report.
a) Conduct three-point calibration of all flow meters in the system.

3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop. Verify flow rate with a clamp on-type flow meter. Provide both values on final report.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.
d. Record final positions of all manual flow measuring devices.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.
f. Record final positions of all devices.

4. For systems with pressure-independent valves at terminals:
a. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.
b. Test the differential pressure across the valve control port to ensure the PICCV is operating within the pressure independent range.
c. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system differential-pressure set point by reducing the pump speed until a point is reached where a terminal unit is no longer achieving design flow. The final setpoint shall be set to 3 psi greater than the measured differential pressure. Record the critical terminal unit.
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

   a. Re-measure and confirm that total water flow is within design.
   b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
   c. Mark final settings.

10. Verify that memory stops have been set.

D. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
3. Adjust pumps to deliver total design gpm.

   a. Measure total water flow.

      1) Position valves for full flow through coils.
      2) Measure flow by main flow meter, if installed. Verify flow rate from measured meter with a clamp on-type flow meter. Provide both values on final report.
      3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop. Verify flow rate from measurement with a clamp on-type flow meter. Provide both values on final report.

   b. Measure pump TDH as follows:

      1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
      2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
      3) Convert pressure to head and correct for differences in gage heights.
      4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

   a. Measure flow in main and branch pipes.
   b. Adjust main and branch balance valves for design flow.
   c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

   a. Measure flow at terminals.
   b. Adjust each terminal to design flow.
   c. Re-measure each terminal after it is adjusted.
   d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
   e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

   a. Measure differential pressure, and verify that it is within manufacturer's specified range.
   b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

   a. Measure and balance coils by either coil pressure drop or temperature method.
   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point, by reducing the pump speed until a point is reached where a terminal unit is no longer achieving design flow. The final setpoint shall be set to 3 psi greater than the measured differential pressure.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.

b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
c. Mark final settings.

13. Verify that memory stops have been set.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first.

B. Balance the secondary circuits after the primary circuits are complete.

3.11 PROCEDURES FOR STEAM SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

D. Check settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.12 PROCEDURES FOR HEAT EXCHANGERS

A. Adjust water flow to within specified tolerances.

B. Measure inlet and outlet water temperatures.

C. Measure and record pressure drop of all circuits.

D. Measure inlet steam pressure.

E. Check settings and operation of safety and relief valves. Record settings.

3.13 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.

6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.14 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.15 Building Pressure Testing

A. Tests shall be performed in conjunction with the ATC contractor.

B. Tests shall be conducted in cooling mode (with each AHU at design cooling volume), and heating mode (with each AHU at minimum airflow condition).

C. All individual sources of OA delivered and EA removed from the building shall be tabulated and presented in the final TAB report.

D. All exterior doors shall remain closed during testing procedure.

E. Provide 5 sample measurements at locations throughout the building.

F. TAB contactor shall work with the ATC contractor to modify the volumetric offset setpoints to achieve a building pressurization level of .03" W.C.

3.16 SOUND TESTS

A. After the systems are balanced and construction is Substantially Complete, measure and record sound levels at 5 locations as designated by the Architect.

B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (LEQ).
3. The sound-testing meter must be capable of using 1/3 octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment operating.
7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:

a. Location.
b. System tested.
c. dBA reading.

d. Sound pressure level in each octave band with equipment on and off.

2. Plot sound pressure levels on NC worksheet with equipment on and off.

3.17 VIBRATION TESTS

A. After systems are balanced and construction is Substantially Complete, measure and record vibration levels on equipment having motor horsepower equal to or greater than 10.

B. Instrumentation:

1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
4. Verify calibration date is current for vibration meter before taking readings.

C. Test Procedures:

1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.
3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record CPM or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:

1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.
3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from the AABC National Standards. Acceptable levels of vibration are normally "smooth" to "good."
4. Include in report General Machinery Vibration Severity Chart, with conditions plotted.

3.18 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.19 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.20 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.21 PRE-BALANCING

3.22 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.23 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare monthly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.24 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.

b. Conditions of filters.
c. Cooling coil, wet- and dry-bulb conditions.
d. Face and bypass damper settings at coils.
e. Fan drive settings including settings and percentage of maximum pitch diameter.
f. Inlet vane settings for variable-air-volume systems.
g. Settings for supply-air, static-pressure controller.
h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.

d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. Outdoor airflow in cfm.
j. Return airflow in cfm.
k. Outdoor-air damper position.
l. Return-air damper position.
m. Vortex damper position.
a. Air flow measurement station calibration data for 100%, 75% and 50% rated flow (TAB measured value and BAS indicated value must both be included in report)
b. Energy recovery device static pressure differential.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm.
i. Face area in sq. ft..
j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h.
b. Airflow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.
a. VFD/ECM speed.

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.

f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

K. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.
a. Final damper position for design flow.

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Service.
    d. Make and size.
    e. Model number and serial number.
    f. Water flow rate in gpm.
    g. Water pressure differential in feet of head or psig.
    h. Required net positive suction head in feet of head or psig.
    i. Pump rpm.
    j. Impeller diameter in inches.
    k. Motor make and frame size.
    l. Motor horsepower and rpm.
    m. Voltage at each connection.
    n. Amperage for each phase.
    o. Full-load amperage and service factor.
    p. Seal type.

2. Test Data (Indicated and Actual Values):

    a. Static head in feet of head or psig.
    b. Pump shutoff pressure in feet of head or psig.
    c. Actual impeller size in inches.
    d. Full-open flow rate in gpm.
    e. Full-open pressure in feet of head or psig.
    f. Final discharge pressure in feet of head or psig.
    g. Final suction pressure in feet of head or psig.
    h. Final total pressure in feet of head or psig.
    i. Final water flow rate in gpm.
    j. Voltage at each connection.
    k. Amperage for each phase.
    a. Water flow measurement station calibration data for 100%, 75% and 50% rated flow (TAB measured value and BAS indicated value must both be included in report).

N. Building Pressurization Data
1. Test Data
    a. Outside air conditions temperature and humidity
    b. Outside air wind conditions (speed and direction)
    c. Building pressure sampling locations
    d. Space conditions at sampling locations (temp and humidity)
    e. Measured building pressure
    f. Total building OA flow, EA flow, SA flow, and RA flow at test conditions

O. Room Pressurization Data
1. Test Data
    a. Pressure sampling locations
    b. Room pressure with respect to adjacent spaces

c. Total zone SA flow, EA flow, and RA flow at test conditions
d. Space conditions at sampling locations (temp and humidity)

P. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.25 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Architect commissioning authority.

B. Commissioning authority or architect shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded. Refer to the commissioning specification for additional requirements.
1. Check the following for each system:
a. Measure airflow of at least 10 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure airflow of at least 1 AHU, verify accuracy of airflow stations.
d. Measure system hydronic flow rates of all major systems, verify accuracy of all installed water flow stations.
e. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
f. Verify that balancing devices are marked with final balance position.
g. Note deviations from the Contract Documents in the final report.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.

3. If the second verification also fails, Architect may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.26 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

End of Section

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Section 23 07 13

DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Sustainable Design Submittals:

C. LEED Submittals:

1. Provide manufacturers' or third-party certification of testing to and compliance with the California Department of Public Health (CDPH) Standard method v1.2-2017, that includes the following information:
   a. The exposure scenario used to determine compliance.
   b. The range of total VOCs after 14 days, measured as specified in the CDPH Standard Method v1.2:
      1. 0.5 mg/m^3 or less;

2. Between 0.5 and 5.0 mg/m^3; or
3. 5.0 mg/m^3 or more

c. Laboratory accreditation under ISO/IEC 17025.
d. Claims of compliance for wet-applied products must state the amount applied in mass per surface area

2. Provide MSDS or other manufacturer documentation with disclosure of VOC content for all wet-applied products.

3. Complete "LEED Materials Documentation Sheet" with IEQc2 information for adhesives/sealants installed within the waterproofing membrane.

4. Product Data: For adhesives, indicating VOC content.

5. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.

6. Product Data: For coatings, indicating VOC content.

7. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.

8. Product Data: For sealants, indicating VOC content.

9. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

D. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.

3. Detail application of field-applied jackets.

4. Detail application at linkages of control devices.

E. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Sheet Form Insulation Materials: 12 inches square.

2. Sheet Jacket Materials: 12 inches square.

3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

If retaining "Mockups" Paragraph below, indicate location, size, and other details of mockups on Drawings or by inserts. Revise if only one mockup is required.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. CertainTeed Corporation.
b. Johns Manville; a Berkshire Hathaway company.
c. Knauf Insulation.
d. Manson Insulation Inc.
e. Owens Corning.

G. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. CertainTeed Corporation.
    b. Johns Manville; a Berkshire Hathaway company.
    c. Knauf Insulation.
    d. Manson Insulation Inc.
    e. Owens Corning.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C656, Type II, Grade 6. Tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Johns Manville; a Berkshire Hathaway company.

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. 3M.
    b. CertainTeed Corporation.
    c. Johns Manville; a Berkshire Hathaway company.
    d. Nelson Firestop; a brand of Emerson Industrial Automation.
    e. Thermal Ceramics.
    f. Unifrax Corporation.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Aeroflex USA.
    b. Armacell LLC.
    c. Foster Brand; H. B. Fuller Construction Products.
    d. K-Flex USA.

2. Verify adhesives have a VOC content of 50 g/L or less.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. Mon-Eco Industries, Inc.

2. Verify fiberglass adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).

D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. Mon-Eco Industries, Inc.

2. Verify adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Johns Manville; a Berkshire Hathaway company.
   b. P.I.C. Plastics, Inc.
   c. Speedline Corporation.
   d. The Dow Chemical Company.

2. Verify adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

1. VOC Content: 300 g/L or less.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Knauf Insulation.
   d. Vimasco Corporation.

2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.

3. Service Temperature Range: Minus 20 to plus 180 deg F.

4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.

5. Color: White.

C. Vapor-Retarder Mastic: Solvent based; suitable for indoor use on below ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. Mon-Eco Industries, Inc.

2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.

3. Service Temperature Range: 0 to 180 deg F.

4. Color: White.

D. Vapor-Retarder Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.

2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.

3. Service Temperature Range: Minus 50 to plus 220 deg F.

4. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. Knauf Insulation.
   e. Mon-Eco Industries, Inc.
   f. Vimasco Corporation.

2. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.

4. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Vimasco Corporation.

2. Verify adhesives have a VOC content of 50 g/L or less.
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.

4. Service Temperature Range: 0 to plus 180 deg F.

5. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.

d. Mon-Eco Industries, Inc.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.

5. Color: Aluminum.
6. Verify sealant has a VOC content of 420 g/L or less.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Childers Brand; H. B. Fuller Construction Products.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.

5. Color: White.

6. Verify sealant has a VOC content of 420 g/L or less.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Childers Brand; H. B. Fuller Construction Products.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Foster Brand; H. B. Fuller Construction Products.
b. Vimasco Corporation.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Alpha Associates, Inc.

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Johns Manville; a Berkshire Hathaway company.
b. P.I.C. Plastics, Inc.
c. Proto Corporation.
d. Speedline Corporation.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.

D. Metal Jacket:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. RPR Products, Inc.

2. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

    a. Sheet and roll stock ready for shop or field sizing.
    b. Finish and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
    d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.

3. Stainless-Steel Jacket: ASTM A167 or ASTM A240/A240M.

    a. Sheet and roll stock ready for shop or field sizing.
    b. Material, finish, and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
    d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.

E. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Polyguard Products, Inc.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Avery Dennison Corporation, Specialty Tapes Division.
    b. Compac Corporation.
    c. Ideal Tape Co., Inc., an American Biltrite Company.
    d. Knauf Insulation.
    e. Venture Tape.

2. Width: 3 inches.

3. Thickness: 11.5 mils.

4. Adhesion: 90 ounces force/inch in width.

5. Elongation: 2 percent.

6. Tensile Strength: 40 lbf/inch in width.

7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Avery Dennison Corporation, Specialty Tapes Division.
   b. Compac Corporation.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.
   e. Venture Tape.

2. Width: 3 inches.

3. Thickness: 6.5 mils.

4. Adhesion: 90 ounces force/inch in width.

5. Elongation: 2 percent.

6. Tensile Strength: 40 lbf/inch in width.

7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Compac Corporation.
   b. Ideal Tape Co., Inc., an American Biltrite Company.
   c. Venture Tape.

2. Width: 2 inches.

3. Thickness: 6 mils.

4. Adhesion: 64 ounces force/inch in width.

5. Elongation: 500 percent.

6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Avery Dennison Corporation, Specialty Tapes Division.
   b. Compac Corporation.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.
   e. Venture Tape.

2. Width: 2 inches.

3. Thickness: 3.7 mils.

4. Adhesion: 100 ounces force/inch in width.

5. Elongation: 5 percent.

6. Tensile Strength: 34 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. ITW Insulation Systems; Illinois Tool Works, Inc.
   b. RPR Products, Inc.

2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal.

3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      1) AGM Industries, Inc.

2) Gemco.
3) Hardcast; a Carlisle Company.
4) Midwest Fasteners, Inc.
5) Nelson Stud Welding.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      1) AGM Industries, Inc.
      2) CL WARD & Family Inc.
      3) Gemco.
      4) Hardcast; a Carlisle Company.
      5) Midwest Fasteners, Inc.
      6) Nelson Stud Welding.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      1) AGM Industries, Inc.
      2) Gemco.
      3) Midwest Fasteners, Inc.

   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      1) Gemco.
      2) Midwest Fasteners, Inc.

b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) AGM Industries, Inc.
2) Gemco.
3) Hardcast; a Carlisle Company.
4) Midwest Fasteners, Inc.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) AGM Industries, Inc.
2) Gemco.
3) Hardcast; a Carlisle Company.
4) Midwest Fasteners, Inc.
5) Nelson Stud Welding.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Gemco.
2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. C & F Wire.

2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A167 or ASTM A240/A240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.

4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 078413 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.

2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied

in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area. Revise first subparagraph below to allow adhesive to be omitted from top surface of horizontal rectangular ducts.

   2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

   3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

      a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
      b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
      c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
      d. Do not overcompress insulation during installation.
      e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

   4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

      a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.

3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.

2. Install lap or joint strips with same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with

weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.7 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.8 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.11 INDOOR DUCT INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

B. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

C. Concealed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.
2. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

D. Concealed, round and flat-oval, exhaust-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

E. Concealed, rectangular, supply-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

F. Concealed, rectangular, return-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

G. Concealed, rectangular, outdoor-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

H. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

I. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

J. Concealed, outdoor-air plenum insulation shall be one of the following:
1. Mineral-Fiber Board: 6.0 pounds per cubic foot density, R-8 (hr.ft^2.F)/Btu minimum, factory applied vapor barrier..

K. Concealed, exhaust-air plenum insulation shall be one of the following:
1. Mineral-Fiber Board: 6.0 pounds per cubic foot density, R-8 (hr.ft^2.F)/Btu minimum, factory applied vapor barrier..

L. Exposed, round and flat-oval, supply-air duct insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.
2. Mineral-Fiber Pipe and Tank: 2 inches thick.

Exposed, round and flat-oval, return-air duct insulation shall be one of the following:
3. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.
4. Mineral-Fiber Pipe and Tank: 2 inches thick.

M. Exposed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.
2. Mineral-Fiber Pipe and Tank: 2 inches thick.

N. Exposed, round and flat-oval, exhaust-air duct insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.
2. Mineral-Fiber Pipe and Tank: 1-1/2 inches thick.

O. Exposed, rectangular, supply-air duct insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

P. Exposed, rectangular, return-air duct insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

Q. Exposed, rectangular, outdoor-air duct insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

R. Exposed, rectangular, exhaust-air duct insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Installed minimum R-Value = 6 (hr.ft^2.F)/Btu.

S. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

T. Exposed, outdoor-air plenum insulation shall be one of the following:
1. Mineral-Fiber Board: 6.0 pounds per cubic foot density, R-8 (hr.ft^2.F)/Btu minimum, factory applied vapor barrier..

U. Exposed, exhaust-air plenum insulation shall be one of the following:
1. Mineral-Fiber Board: 6.0 pounds per cubic foot density, R-8 (hr.ft^2.F)/Btu minimum, factory applied vapor barrier..

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:
1. PVC: 30 mils thick.
2. Aluminum, Smooth: 0.024 inch thick.

D. Ducts and Plenums, Exposed:
1. PVC: 30 mils thick.
2. Aluminum, Smooth: 0.024 inch thick.

End of Section

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Section 23 07 16

HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Insulation shall be installed throughout the length of equipment and piping, including fittings, valves and specialties. Except for removable covers on pumps, Insulation shall be permanently installed on piping specialties such as valves, flanges, unions, p/t test ports, strainers, steam PRV stations, heads/bodies on steam to hot water converters and water to water heat exchangers, steam traps, control valves including actuators and gear boxes, low point drain valves, expansion/compression tanks and air separators. A label shall be provided identifying the location of the pipe specialty.

B. Section includes insulating the following HVAC equipment that is not factory insulated:
1. Heating, hot-water pumps.
2. Expansion/compression tanks.
3. Air separators.
4. Piping system filtration unit housings.
5. Heat Exchangers (including plate frame, shell tube, converters).
6. Pressure-reducing valves, Pressure-reducing stations
7. Duplex Condensate Return Pump Package

C. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. LEED Submittals:
1. Provide manufacturers' or third-party certification of testing to and compliance with the California Department of Public Health (CDPH) Standard method v1.2-2017, that includes the following information:
   - The exposure scenario used to determine compliance.
   - The range of total VOCs after 14 days, measured as specified in the CDPH Standard Method v1.2:

- 0.5 mg/m^3 or less;
- Between 0.5 and 5.0 mg/m^3; or
- 5.0 mg/m^3 or more

- Laboratory accreditation under ISO/IEC 17025.
- Claims of compliance for wet-applied products must state the amount applied in mass per surface area

2. Provide MSDS or other manufacturer documentation with disclosure of VOC content for all wet-applied products.

3. Complete "LEED Materials Documentation Sheet" with IEQc2 information for adhesives/sealants installed within the waterproofing membrane.

4. Product Data: For adhesives, indicating VOC content.

5. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.

6. Product Data: For coatings, indicating VOC content.

7. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.

8. Product Data: For sealants, indicating VOC content.

9. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

2. Detail attachment and covering of heat tracing inside insulation.

3. Detail removable insulation at equipment connections.

4. Detail application of field-applied jackets.

5. Detail application at linkages of control devices.

6. Detail field application for each equipment type.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN 50).

2. Sheet Form Insulation Materials: 12 inches (300 mm) square.

3. Sheet Jacket Materials: 12 inches (300 mm) square.

4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Equipment Mockups:

a. One heating-hot-water pump.
b. One tank or vessel.

2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.

3. Notify Architect seven days in advance of dates and times when mockups will be constructed.

4. Obtain Architect's approval of mockups before starting insulation application.

5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

7. Demolish and remove mockups when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

1.9 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

A. Calcium Silicate:

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Industrial Insulation Group (IIG); Thermo-12 Gold.
    b. Approved equal

2. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

B. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Pittsburgh Corning Corporation; Foamglas.
    b. Approved equal

2. Block Insulation: ASTM C 552, Type I.

3. Special-Shaped Insulation: ASTM C 552, Type III.

4. Board Insulation: ASTM C 552, Type IV.

5. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

C. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Aeroflex USA, Inc.; Aerocel.
    b. Armacell LLC; AP Armaflex.
    c. K-Flex USA; Insul-Sheet and K-FLEX LS.
    d. Approved equal

D. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290 Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. CertainTeed Corp.; SoftTouch Duct Wrap.
    b. Johns Manville; Microlite.
    c. Knauf Insulation; Friendly Feel Duct Wrap.
    d. Owens Corning; SOFTR All-Service Duct Wrap.
    e. Approved equal

E. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Industrial Insulation Group (IIG); MinWool-1200 Flexible Batt.
b. Johns Manville; HTB 26 Spin-Glas.
c. Roxul Inc.; Roxul RW.
d. Approved equal

F. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. CertainTeed Corp.; CertaPro Commercial Board.
b. Johns Manville; 800 Series Spin-Glas.
c. Knauf Insulation; Insulation Board.
d. Owens Corning; Fiberglas 700 Series.
e. Approved equal

G. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Fibrex Insulations Inc.; FBX.Industrial Insulation Group (IIG); MinWool-1200 Industrial Board.
b. Rock Wool; Delta Board.
c. Thermafiber, Inc.; Thermafiber Industrial Felt.
d. Approved equal

H. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Johns Manville; Micro-Lok.
b. Knauf Insulation; 1000-Degree Pipe Insulation.
c. Owens Corning; Fiberglas Pipe Insulation.
d. Approved equal

I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with

ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. CertainTeed Corp.; CrimpWrap.
    b. Johns Manville; MicroFlex.
    c. Knauf Insulation; Pipe and Tank Insulation.
    d. Owens Corning; Fiberglas Pipe and Tank Insulation.
    e. Approved equal

J. Phenolic:

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Kingspan Tarec Industrial Insulation NV; Koolphen K.
    b. Resolco International BV; Insul-phen.
    c. Approved equal

2. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.

3. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

4. Factory-Applied Jacket: ASJ. Requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Ramco Insulation, Inc.; Super-Stik.
    b. Approved equal

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Ramco Insulation, Inc.; Thermokote V.
    b. Approved equal

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.
    b. Approved equal

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97.
    b. Eagle Bridges - Marathon Industries; 290.
    c. Mon-Eco Industries, Inc.; 22-30.
    d. Approved equal

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.
    b. Approved equal

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Phenolic and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-33.
   c. Approved equal

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   c. K-Flex USA; R-373 Contact Adhesive.
   d. Approved equal

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Mon-Eco Industries, Inc.; 22-25.
   d. Approved equal

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

G. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60.
   c. Approved equal

H. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Mon-Eco Industries, Inc.; 22-25.
   d. Approved equal

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

I. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Dow Corning Corporation; 739, Dow Silicone.
   b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
   c. Speedline Corporation; Polyco VP Adhesive.
   d. Approved equal

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H .B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.
c. Approved equal

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.

4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
b. Eagle Bridges - Marathon Industries; 501.
c. Mon-Eco Industries, Inc.; 55-10.
d. Approved equal

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.

3. Service Temperature Range: 0 to 180 deg F.

4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.

5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
b. Eagle Bridges - Marathon Industries; 570.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
d. Approved equal

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.

3. Service Temperature Range: Minus 50 to plus 220 deg F.

4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.

5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
b. Eagle Bridges - Marathon Industries; 550.
c. Mon-Eco Industries, Inc.; 55-50.
d. Approved equal

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.

4. Solids Content: 60 percent by volume and 66 percent by weight.

5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
   c. Vimasco Corporation; 713 and 714.
   d. Approved equal

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.

4. Service Temperature Range: 0 to plus 180 deg F.

5. Color: White.

2.6 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Pittsburgh Corning Corporation; Pittseal 444.
   d. Approved equal

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Mon-Eco Industries, Inc.; 44-05.
   d. Approved equal

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.

5. Color: Aluminum.

6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Approved equal

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.

5. Color: White.

6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

5. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
        2) Approved equal

6. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

        2) Approved equal

7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

    a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
        2) Approved equal

8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering equipment.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas No. 5.
    b. Approved equal

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for equipment.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.
c. Approved equal

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.
b. Approved equal

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Speedline Corporation; SmokeSafe.
d. Approved equal

2. Adhesive: As recommended by jacket material manufacturer.

3. Color: White.

4. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
    b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
    c. RPR Products, Inc.; Insul-Mate.
    d. Approved equal

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

    a. Sheet and roll stock ready for shop or field sizing.
    b. Finish and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
    d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
    e. Factory-Fabricated Fitting Covers:

        1) Same material, finish, and thickness as jacket.
        2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
        3) Tee covers.
        4) Flange and union covers.
        5) End caps.
        6) Beveled collars.
        7) Valve covers.
        8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

    a. Sheet and roll stock ready for shop or field sizing.
    b. Material, finish, and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
    d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
    e. Factory-Fabricated Fitting Covers:

        1) Same material, finish, and thickness as jacket.
        2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
        3) Tee covers.
        4) Flange and union covers.
        5) End caps.
        6) Beveled collars.
        7) Valve covers.
        8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with stucco-embossed aluminum-foil facing.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Polyguard Products, Inc.; Alumaguard 60.
    b. Flex-Clad.
    c. Approved equal

F. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
    a. Dow Chemical Company (The), Saran 540 Vapor Retarder Film. Approved equal
    b. Approved equal

G. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Dow Chemical Company (The), Saran 560 Vapor Retarder Film.
    b. Approved equal

H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
    b. Approved equal

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. ABI, Ideal Tape Division; 428 AWF ASJ.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
    c. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
    d. Approved equal

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. ABI, Ideal Tape Division; 491 AWF FSK.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    c. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
    d. Approved equal

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. ABI, Ideal Tape Division; 370 White PVC tape.
    b. Compac Corporation; 130.
    c. Venture Tape; 1506 CW NS.
    d. Approved equal

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. ABI, Ideal Tape Division; 488 AWF.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
    c. Venture Tape; 3520 CW.
    d. Approved equal

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.
    b. Approved equal

2. Width: 3 inches.
3. Film Thickness: 4 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.
    b. Approved equal

2. Width: 3 inches.
3. Film Thickness: 6 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
c. Approved equal

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.

a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1) AGM Industries, Inc.; CWP-1.
2) Midwest Fasteners, Inc.; CD.
3) Nelson Stud Welding; TPA, TPC, and TPS.
4) Approved equal

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1) AGM Industries, Inc.; CHP-1.
2) Midwest Fasteners, Inc.; Cupped Head.
3) Nelson Stud Welding; CHP.
4) Approved equal

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
2) GEMCO; Perforated Base.
3) Midwest Fasteners, Inc.; Spindle.
4) Approved equal

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.

d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

   a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

      1) GEMCO; Nylon Hangers.
      2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
      3) Approved equal

   b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
   c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

   a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

      1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers, Series.
      2) GEMCO; Peel & Press.
      3) Midwest Fasteners, Inc.; Self Stick.
      4) Approved equal

   b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

   a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

      1) AGM Industries, Inc.; RC-150.
      2) Midwest Fasteners, Inc.; WA-150.
      3) Nelson Stud Welding; Speed Clips.
      4) Approved equal

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) GEMCO.
2) Midwest Fasteners, Inc.
3) Approved equal

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.080-inch nickel-copper alloy.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. C & F Wire.
b. Approved equal

2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to

structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.

a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.

2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.

3. Protect exposed corners with secured corner angles.

4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
   d. Do not overcompress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches (75 mm).

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.

2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Pumps to be insulated with flexible elastomeric insulation, to be adhered directly to pump housing.
2. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Generator Breechings:

1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation material.

2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.6 INSTALLATION OF PHENOLIC INSULATION

A. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.

B. Install two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.

3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.

2. Install lap or joint strips with same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.

2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.8 FINISHES

A. Flexible elastomeric insulation shall be adhered to 100% of the pipeEquipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

C. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

D. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

E. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 BREECHING INSULATION SCHEDULE

A. Round, exposed breeching and connector insulation shall be one of the following:

1. Calcium Silicate: 4 inches (100 mm) thick.

2. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

3. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

B. Round, concealed breeching and connector insulation shall be one of the following:

1. Calcium Silicate: 4 inches (100 mm) thick.

2. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

3. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

C. Rectangular, exposed breeching and connector insulation shall be one of the following:

1. Calcium Silicate: 4 inches (100 mm) thick.

2. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

3. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

D. Rectangular, concealed breeching and connector insulation shall be one of the following:

1. Calcium Silicate: 4 inches (100 mm) thick.

2. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

3. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

3.11 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Heating-hot-water pump insulation shall be one of the following:

1. Cellular Glass: 3 inches thick.

2. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

D. Heating-hot-water expansion/compression tank insulation shall be one of the following:

1. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.

2. Mineral-Fiber Pipe and Tank: 1 inch thick.

E. Heating-hot-water air-separator insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

2. Mineral-Fiber Pipe and Tank: 2 inches thick.

F. Piping system filter-housing insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

2. Mineral-Fiber Pipe and Tank: 2 inches thick.

G. Heat Exchanger (shell and tube steam) insulation shall be one of the following:

1. Mineral-Fiber Board: 5 inches thick and 3-lb/cu. ft. nominal density.

2. Mineral-Fiber Pipe and Tank: 5 inches thick.

H. Heat Exchanger (all other types) insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

2. Mineral-Fiber Pipe and Tank: 2 inches thick.

I. Pressure-reducing valves, Pressure-reducing stations
1. Match steam piping insulation serving PRV / PRV stations, refer to 230719.

J. Duplex Condensate Return Pump Package
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

2. Mineral-Fiber Pipe and Tank: 2 inches thick.

K. Insulation, Interior, Condensate and Equipment Drain Water below 75F.

All sizes => 1" fiberglass OR flexible elastomeric

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:

1. PVC, Color-Coded by System: 30 mils thick.

2. Aluminum, Corrugated: 0.020 inch thick.

D. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):

1. PVC, Color-Coded by System: 30 mils thick.

2. Aluminum, Corrugated: 0.024 inch thick.

E. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):

1. Painted Aluminum, Smooth with 1-1/4-Inch- (32-mm) Deep Corrugations 0.040 inch (1.0 mm) thick.

End of Section

Section 23 07 19

HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Where there are discrepancies between these specifications and the University standards, University standards shall govern unless specifically directed by the engineer.

1.2 SUMMARY

A. Insulation shall be installed throughout the length of equipment and piping, including fittings, valves and specialties. Except for removable covers on pumps, Insulation shall be permanently installed on piping specialties such as valves, flanges, unions, p/t test ports, strainers, steam PRV stations, heads/bodies on steam to hot water converters and water to water heat exchangers, steam traps, control valves including actuators and gear boxes, low point drain valves, expansion/compression tanks and air separators. A label shall be provided identifying the location of the pipe specialty.

B. Section includes insulating the following HVAC piping systems:
1. Condensate drain piping, indoors.
2. Chilled-water piping, indoors and outdoors.
3. Heating hot-water piping, indoors and outdoors.
4. Steam and steam condensate piping, indoors and outdoors.
5. Refrigerant Liquid, Suction and Hot-Gas Piping.

C. Related Sections:
1. Section 078413 “Penetration Firestopping”.
2. Section 230713 "Duct Insulation."
3. Section 230716 "HVAC Equipment Insulation."
4. Section 230533 “Heat tracing for hvac piping.”

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. LEED Submittals:

1. Provide manufacturers' or third-party certification of testing to and compliance with the California Department of Public Health (CDPH) Standard method v1.2-2017, that includes the following information:
   - The exposure scenario used to determine compliance.
   - The range of total VOCs after 14 days, measured as specified in the CDPH Standard Method v1.2:
     - 0.5 mg/m^3 or less;
     - Between 0.5 and 5.0 mg/m^3; or
     - 5.0 mg/m^3 or more
   - Laboratory accreditation under ISO/IEC 17025.
   - Claims of compliance for wet-applied products must state the amount applied in mass per surface area
2. Provide MSDS or other manufacturer documentation with disclosure of VOC content for all wet-applied products.
3. Complete "LEED Materials Documentation Sheet" with IEQc2 information for adhesives/sealants installed within the waterproofing membrane.

4. Product Data: For adhesives, indicating VOC content.
5. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
6. Product Data: For coatings, indicating VOC content.
7. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.
8. Product Data: For sealants, indicating VOC content.
9. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.
   1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
   2. Sheet Form Insulation Materials: 12 inches square.
   3. Jacket Materials for Pipe: 12 inches long by NPS 2.
   4. Sheet Jacket Materials: 12 inches square.
   5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Delegated-Design Submittal:

   1. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
   1. Piping Mockups:
      a. One 10-foot section of NPS 2 straight pipe.
      b. One each of a 90-degree threaded, welded, and flanged elbow.
      c. One each of a threaded, welded, and flanged tee fitting.
      d. One NPS 2 or smaller valve, and one NPS 2-1/2 or larger valve.
      e. Four support hangers including hanger shield and insert.
      f. One threaded strainer and one flanged strainer with removable portion of insulation.
      g. One threaded reducer and one welded reducer.
      h. One pressure temperature tap.
      i. One mechanical coupling.
   2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
   3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
   4. Obtain Architect's approval of mockups before starting insulation application.
   5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
   7. Demolish and remove mockups when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

1.9 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Industrial Insulation Group (IIG); Thermo-12 Gold.
      b. Approved Equal.
   2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
   3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
   4. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Pittsburgh Corning Corporation; Foamglas.
      b. Approved Equal.
   2. Block Insulation: ASTM C 552, Type I.
   3. Special-Shaped Insulation: ASTM C 552, Type III.
   4. Board Insulation: ASTM C 552, Type IV.
   5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
   6. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
   7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

H. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Aeroflex USA, Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.
      d. Approved Equal.

I. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. CertainTeed Corp.; SoftTouch Duct Wrap.
      b. Johns Manville; Microlite.

c. Owens Corning; SOFTR All-Service Duct Wrap.
d. Approved Equal.

J. Mineral-Fiber, Preformed Pipe Insulation:
1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Fibrex Insulations Inc.; Coreplus 1200.
b. Johns Manville; Micro-Lok.
c. Owens Corning; Fiberglas Pipe Insulation.
d. Approved Equal.
2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

K. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Owens Corning; Fiberglas Pipe and Tank Insulation.
d. Approved Equal.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Ramco Insulation, Inc.; Super-Stik.
b. Approved Equal.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Ramco Insulation, Inc.; Thermokote V.
b. Approved Equal.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.
b. Approved Equal.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.
1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97.
b. Eagle Bridges - Marathon Industries; 290.
c. Vimasco Corporation; 760.
d. Approved Equal.
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.
b. Approved Equal.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Aeroflex USA, Inc.; Aeroseal.
b. Armacell LLC; Armaflex 520 Adhesive.
c. K-Flex USA; R-373 Contact Adhesive.
d. Approved Equal.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile

Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
      b. Eagle Bridges - Marathon Industries; 225.
      c. Mon-Eco Industries, Inc.; 22-25.
      d. Approved Equal.
   2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
      b. Eagle Bridges - Marathon Industries; 225.
      c. Mon-Eco Industries, Inc.; 22-25.
      d. Approved Equal.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

G. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Dow Corning Corporation; 739, Dow Silicone.
      b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
      c. P.I.C. Plastics, Inc.; Welding Adhesive.
      d. Approved Equal.

   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
      b. Vimasco Corporation; 749.
      c. Approved Equal.
   2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
   5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
      b. Eagle Bridges - Marathon Industries; 501.
      c. Mon-Eco Industries, Inc.; 55-10.
      d. Approved Equal.

   2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
   3. Service Temperature Range: 0 to 180 deg F.
   4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
   5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
      b. Eagle Bridges - Marathon Industries; 570.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
      d. Approved Equal.
   2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
   3. Service Temperature Range: Minus 50 to plus 220 deg F.
   4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
   5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
   b. Eagle Bridges - Marathon Industries; 550.
   c. Mon-Eco Industries, Inc.; 55-50.
   d. Approved Equal.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
   1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
      b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
      c. Vimasco Corporation; 713 and 714.
      d. Approved Equal.
   3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
   4. Service Temperature Range: 0 to plus 180 deg F.
   5. Color: White.

2.6 SEALANTS

A. Joint Sealants:
   1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
      b. Eagle Bridges - Marathon Industries; 405.
      c. Pittsburgh Corning Corporation; Pittseal 444.
      d. Approved Equal.

   2. Joint Sealants for Polystyrene Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-70.
      b. Eagle Bridges - Marathon Industries; 405.

c. Mon-Eco Industries, Inc.; 44-05.
d. Approved Equal.

3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 deg F.
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. Eagle Bridges - Marathon Industries; 405.
c. Mon-Eco Industries, Inc.; 44-05.
d. Approved Equal.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. Approved Equal.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
   3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
   4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
   5. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
      a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
         1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
         2) Approved Equal.
   6. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
      a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
         1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
         2) Approved Equal.
   7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
      a. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
         1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
         2) Approved Equal.
   8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Products: Subject to compliance with requirements, provide one of the following:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Speedline Corporation; SmokeSafe.
d. Approved Equal.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

D. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with stucco-embossed aluminum-foil facing.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Polyguard Products, Inc.; Alumaguard 60.
      b. Approved Equal.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. ABI, Ideal Tape Division; 428 AWF ASJ.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
      c. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
      d. Approved Equal.
   2. Width: 3 inches.
   3. Thickness: 11.5 mils.
   4. Adhesion: 90 ounces force/inch in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch in width.
   7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. ABI, Ideal Tape Division; 491 AWF FSK.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
      c. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
      d. Approved Equal.
   2. Width: 3 inches.
   3. Thickness: 6.5 mils.
   4. Adhesion: 90 ounces force/inch in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch in width.

7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. ABI, Ideal Tape Division; 370 White PVC tape.
      b. Compac Corporation; 130.
      c. Venture Tape; 1506 CW NS.
      d. Approved Equal.
   2. Width: 2 inches.
   3. Thickness: 6 mils.
   4. Adhesion: 64 ounces force/inch in width.
   5. Elongation: 500 percent.
   6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. ABI, Ideal Tape Division; 488 AWF.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
      c. Venture Tape; 3520 CW.
      d. Approved Equal.
   2. Width: 2 inches.
   3. Thickness: 3.7 mils.
   4. Adhesion: 100 ounces force/inch in width.
   5. Elongation: 5 percent.
   6. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.
      b. Approved Equal.
   2. Width: 3 inches.
   3. Film Thickness: 4 mils.
   4. Adhesive Thickness: 1.5 mils.
   5. Elongation at Break: 145 percent.
   6. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
   1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.
      b. Approved Equal.
   2. Width: 3 inches.
   3. Film Thickness: 6 mils.
   4. Adhesive Thickness: 1.5 mils.
   5. Elongation at Break: 145 percent.
   6. Tensile Strength: 55 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:
1. Products: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
c. Approved Equal.
2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

C. Wire: 0.080-inch nickel-copper alloy.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. C & F Wire.
b. Approved Equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-

sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.

4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Provide UL Listed and FM approved firestopping for penetrations through rated assemblies in accordance with specification '078413 – Penetration Firestopping'.

F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

a. Provide UL Listed and FM approved firestopping for penetrations through rated assemblies in accordance with specification '078413 – Penetration Firestopping'.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the

insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.

2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Flexible elastomeric insulation shall be adhered to 100% of the pipe.

B. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

E. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.10 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:
1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.11 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
   a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.12 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.13 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.14 INDOOR PIPING INSULATION SCHEDULE

A. Chilled Water:
1. NPS 12 and Smaller: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.

B. Condensate and Equipment Drain Water below 75 Deg F:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric or Fiberglass: 1 inch thick.
      b. Preformed Pipe Insulation with Factory Applied ASJ: 3/4 inch thick.
      c. Fiberglass to be used where piping is exposed.

C. Heating-Hot-Water Supply and Return:
   1. NPS 1-1/4 and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.

   2. NPS 1-1/2 and Larger: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

D. Steam and Steam Condensate, 350 Deg F (177 Deg C) and Below:
   1. NPS 12 and Smaller: Insulation shall be one of the following:
      a. Calcium Silicate: 4.5 inches thick.
      b. Cellular Glass: 4.5 inches thick.
      c. Mineral-Fiber, Preformed Pipe, Type I or II: 4.5 inches thick.

E. Steam and Steam Condensate, above 350 Deg F (177 Deg C):
   1. NPS 12 and Smaller: Insulation shall be one of the following:
      a. Calcium Silicate: 5 inches thick.
      b. Cellular Glass: 5 inches thick.
      c. Mineral-Fiber, Preformed Pipe, Type I or II: 5 inches thick.

F. Refrigerant Liquid, Suction and Hot-Gas Piping:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.
      b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1.5 inch thick.

3.15 OUTDOOR PIPING INSULATION SCHEDULE, including piping installed in AHU / RTU service enclosures at roof level:

A. Chilled Water:
   1. NPS 12 and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 3 inches thick.

B. Heating-Hot-Water Supply and Return:
   1. NPS 12 and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 3 inches thick.

3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Piping, Concealed:
   1. None.

C. Piping, Exposed:

1. PVC: 20 mils thick.

3.17 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE, including piping installed in AHU / RTU service enclosures at roof level:

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Piping, Concealed:
1. PVC: 30 mils thick.

C. Piping, Exposed:
1. PVC: 30 mils thick.

End of Section

SECTION 23 08 00
HVAC SYSTEM COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes: The Work of this Section shall include but not be limited to the following:

1. Systems and equipment Start-Up and Functional Performance Testing.
2. Validation of proper and thorough installation of Division 23 systems and equipment.
3. Generic Start-Up Documentation for mechanical systems and equipment.
4. Development of final Start-Up Documentation for mechanical systems and equipment.
5. System Start-Up and Turn-Over procedures.
6. Systems balancing verification.
7. Coordination and execution of Training Events.

B. Related Sections

1. The Cx process references many related Sections, particularly Section 01 91 00 - General Commissioning. It is important for all Contractors subject to the Cx process to be familiar with Section 01 91 00.
2. Refer to Section 01 91 00 for a complete list of Sections on Related Work.

1.3 GENERAL DESCRIPTION

A. Commissioning (Cx) is the process of ensuring that (i) all building systems are installed and perform interactively according to the design intent; (ii) that systems are efficient and cost effective and meet the Owner’s operational needs; (iii) that the installation is accurately documented; and (iv) that the Operators are adequately trained. Commissioning serves as a tool to minimize post-occupancy operational problems, and establishes testing and communication protocols to advance the building systems from installation to optimized, fully-dynamic operation.

B. Commissioning Authority (CxA) shall work with the Contractor and the design engineers to direct and oversee the Cx process and perform Functional Performance Testing.

C. The Commissioning Plan outlines the Cx process beyond the Construction Contract, including design phase activities and design team/owner responsibilities. The specification Sections dictate all requirements of the commissioning process relative to the construction contract. The Cx Plan is not part of the construction contract, although it is available for reference at the request of the Contractor.

D. This Section outlines the Cx procedures specific to the Division 23 Contractors. Requirements common to all Sections are specified in Section 01 91 00 and Section 01 91 10 This Section and other sections of the specification details the Contractor's responsibilities relative to the Cx process.

1.4 SCOPE

A. The following systems and equipment are included in the Scope of Commissioning for this project:

B. Mechanical/HVAC Systems: All Division 23 equipment and systems are subject to commissioning, including but not limited to the systems listed below. All components and devices (sensors, valves, etc.) that make up these systems are included.

1. Air Handling Units (AHU)
2. VAV terminal units
3. Fan Coil Units (FCU)
4. CHW Hydronic Pumping System
5. HW Hydronic Pumping System
6. Packaged and Rooftop HVAC Units
7. Converters
8. Heat Exchangers
9. Steam Systems
10. Process Hydronic Systems
11. Supply, Return, Relief, Exhaust Air systems
12. Heat recovery systems

C. Building Automation Systems (BAS)

1. The entire BAS shall be subject to commissioning, including all hardware components, software, networking, programming and engineering services, and controls documentation.

1.5 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 01 91 00 for a complete list of Definitions and Abbreviations.

1.6 REFERENCE STANDARDS

A. Refer to Section 01 91 00 for a complete list of Reference Standards.

1.7 DOCUMENTATION

A. Documentation shall be as required in Section 01 91 00. In addition, Contractor shall also provide to the CxA the following per the procedures specified herein, in the Cx Plan, and in other Sections of the specification:

1. Factory Test Reports: Contractor shall provide any factory testing documentation or certified test reports required by the specifications. These shall be provided prior to the Acceptance Phase. Factory Test Reports should be provided in PDF electronic format. These may include but are not limited to:
    a. Air Handling Units
    b. Fans Capacity
    c. Fan Sound Power Levels
    d. Pump Capacity
2. Field Testing Agency Reports (other than TAB): Provide all documentation of work of independent testing agencies required by the specification. These shall be provided prior to Acceptance Phase. Field Testing Agency Reports should be provided in PDF electronic format. These may include but are not limited to:
    a. Pipe Pressure Testing
    b. Duct Leakage Testing
    c. Water Treatment
3. TAB Plan: The Testing, Adjusting, and Balancing Plan shall include the following:
    a. Certifications on all instruments to be used throughout the testing. Certification must be documented within the previous 6 months.
    b. Résumés and Certification of individuals who will be balancing the systems.
    c. Detailed step-by-step plans for each procedure to be performed by the TAB Contractor.
    d. Sample forms to be used for each measurement.
    e. Sample balancing report.
4. Piping Cleaning, Flush, and Fill Plan: Contractor shall provide this document in accordance with details in this Section. CxA will review.
5. Temporary Operating and Conditioning Plan: Contractor shall provide in accordance with details in this Section. CxA will review.
6. Completed TAB Reports. CxA will review prior to FPT.

1.8 SEQUENCING AND SCHEDULING

A. Refer to Section 01 91 00.

1.9 COORDINATION MANAGEMENT PROTOCOLS

A. Coordination responsibilities and management protocols relative to Cx are initially defined in Section 01 91 00 and the Cx Plan, but shall be refined and documented in the Construction

Phase Cx Kick-Off Meeting. Contractor shall have input into the protocols to be used and all Parties will commit to scheduling obligations. The CxA will record and distribute.

1.10 CONTRACTOR RESPONSIBILITIES

A. Refer to Section 01 91 00: Detailed Contractor responsibilities common to all Divisions are specified in Section 01 91 00. The following are additional responsibilities or notable responsibilities specific to Division 23.

B. Construction Phase

1. Provide skilled technicians qualified to perform the work required.
2. Provide factory-trained and authorized technicians where required by the Contract Documents.
3. Prepare and submit required draft Start-Up Documentation and submit along with the manufacturer's application, installation and start-up information.
4. Provide assistance to the CxA in preparation of the specific Functional Performance Test (FPT) procedures. Contractors, subcontractors and vendors shall review FPT procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests. Damage caused to equipment performed in accordance with the approved procedures will be the responsibility of the Contractor.
5. Thoroughly complete and inspect installation of systems and equipment as detailed throughout Contract Documents, as required by reference or industry standards, and as specifically indicated elsewhere this Section.
6. Start-Up, test/adjust/balance, and Turn-Over systems and equipment prior to functional performance testing by the CxA. Approved Start-Up Documentation shall be in accordance with Contract Documents, reference or industry standards, and specifically elsewhere in Part I of this Section.
7. Record Start-Up on approved Start-Up Documentation forms and certify that the systems and equipment have been started and or tested in accordance with the requirements specified above and in Section 01 09 00. Each task or item shall be indicated with the Party actually performing the task or procedure.
8. TAB: As outlined in Section 23 05 93. Specifically as it relates to Cx:
    a. Attend Construction Phase Cx Kick-Off Meeting and Cx progress meetings beginning within 3 months of start of TAB work;
    b. Submit TAB Plan as indicated above;
    c. Meet with Cx team to review TAB procedures and documentation required;
    d. Demonstrate TAB procedures for repetitive tasks (zone balancing, AHU adjusting) as called for by the CxA;
    e. Participate in Action List dialogue;
    f. Provide all documentation electronically.

C. Acceptance Phase

1. Assist CxA in Functional Performance Testing. Assistance will typically include the following:
    a. Manipulate systems and equipment to facilitate Functional Performance Testing (as specified in Section 01 91 00, Section 01 91 10, and the Cx Plan; in some cases this will entail only an initial sample);
    b. Provide any specialized instrumentation necessary for Functional Performance Testing;
    c. Manipulate BAS and other control systems to facilitate Functional Performance Testing (as specified in Section 01 91 00, Section 01 91 10, and the Cx Plan; in some cases this will entail only an initial sample);
    d. Provide a TAB technician to work at the direction of CxA for up to 8 hours beyond assistance specified above.
    e. Provide a BAS technician to work at the direction of CxA for up to 16 hours beyond assistance specified above.

D. Warranty Phase

1. Maintain record documentation of any configurations, setpoints, parameters, etc. that change throughout the Warranty Period.
2. Provide representative for off-season testing as required by CxA.
3. Respond to warranty issues as required by Division 01 and the General Conditions.

1.11 EQUIPMENT SUPPLIER RESPONSIBILITIES

A. Refer to Section 01 91 00.

1.12 CONTRACTOR NOTIFICATION AND SCHEDULING

A. Refer to Section 01 91 00.

1.13 START-UP DOCUMENTATION

A. Refer to Section 01 91 00.

1.14 EQUIPMENT NAMEPLATE DATA

A. Refer to Section 01 91 00.

1.15 PIPING CLEANING, FLUSH, AND FILL PLAN

A. Contractors shall provide a “Piping Cleaning, Flush, and Fill Plan” to the CxA that provides a descriptive narrative and supporting calculations of the means and methods that will be used to clean out, flush, and fill the piping systems. CxA will review and post the final approved document to the Portal.

B. The “Piping Cleaning, Flush, and Fill Plan” shall incorporate and be inclusive of all requirements of individual Sections relating to piping and pipe cleaning and flushing. In addition to the

requirements of any other related Section, this document shall consist of the following at a minimum for each individual hydronic loop:

1. Overview schematic diagram of each of the hydronic systems, showing individual flow components such as chillers, boilers, pumps, heat exchangers, cooling towers, control valves, and strainers.
2. Narrative and illustration indicating the equipment that will either participate or be bypassed by fluid flow during the clean and flush process.
3. For equipment to be bypassed, description of the means for providing the bypass, including the type, size, and length of hoses or piping to be used.
4. Description of how flow is to be induced (permanent pumps, temporary pumps, etc.) and flow rates to be imposed during the flush process.
5. Calculation of resultant flow velocities in various portions of the piping system, with specific identification of the minimum velocity sections of the piping loop. Velocities should generally be shown to be above a 7 feet-per-second minimum speed to provide for adequate capability to flush and carry debris through the system to the appropriate strainer or clean-out location.
6. Description of cleaning methods and materials to be used to flush the system. Description shall include cleaning material and concentration, details of the cleaning process including duration of circulation and flushing intervals, criteria for determining a “clean” flush, and name and qualifications of cleaning or chemical treatment subcontractors to be used.
7. Identification and discussion of any isolated sections or ‘dead-legs’ that will be present, including means to provide cleaning and flushing for these sections.
8. Details of the strainers to be used for the flush and clean process, as well as final strainers to be used after cleaning. Contractor shall clean all strainers prior to turning over the system for commissioning.
9. If the cleaning and flushing process is to be phased in sections, details should be provided to clarify how clean sections will be protected as other sections are flushed.

1.16 TEMPORARY OPERATION AND CONDITIONING PLAN

A. Contractor shall be allowed to use permanent building equipment to provide temporary conditioning ONLY upon the approval of the A/E, Owner, and the CxA. Approval for such will only be given upon acceptance of a detailed Temporary Operating and Conditioning Plan provided by the individually involved subcontractors and compiled by the GC. This Temporary Operating and Conditioning Plan shall be a required element of the Construction IAQ Management Plan required for the LEED Credit EQ 3.1. The Temporary Operating and Conditioning Plan shall consider/address the following at a minimum:

1. Indicate that the full Start-Up protocol, including development and documentation of Start-Up Documentation as required by the specification will be performed for the temporary start-up. The Temporary Conditioning Plan shall include the Start-Up Documentation to be used, which shall be the same as those that will be used for final Start-Up.

2. Contractor shall address how equipment will be maintained in good, clean condition. Specifically address:
    a. Temporary Filtering of Air: Air filters used for construction shall be as or more effective than those specified for permanent use. Contractor shall remove construction filters and replace with new filters prior to FPT. Filters shall be maintained and replaced at the specified final pressure drop. Contractor shall install a magnehelic gauge for visual indication of pressure drop as well as setting and adjusting the loaded filter DP switch for monitoring on the BAS.
    b. Temporary Filtering of Water and Condensate: Construction strainers shall be used while circulating fluid during construction. Construction strainer shall be finer than that specified for final strainers.
    c. Sealing/Filtering of Open Ducts: Address that all open ducts shall be either sealed or protected with filter media. Return or exhaust systems shall not be used during construction unless otherwise approved.
    d. Lubrication and Maintenance: Contractor shall maintain the systems and equipment in accordance with the manufacturer's instructions. Contractor shall coordinate lubricants used with Owner's operators. Frequency of lubrication and inspection shall be as recommended by manufacturer's literature. Applicable maintenance lubrication schedules shall be included in the Plan. Draft maintenance logs shall be submitted with Plan and completed as maintenance is performed.
    e. Operation Outside of Normal Ranges: Systems and equipment shall not be operated outside the range of specified conditions. The Temporary Conditioning Plan shall address how the Contractor will ensure that operation will not harm the equipment.
    f. Emergency Condition Identification and Response Protocols: The Temporary Conditioning Plan shall address protocols for responding to equipment malfunctions and or harmful operation. Automatic safeties and remote enunciation shall be in place to protect people and property. Temporary operation shall not be allowed until there is an automatic communication/enunciation medium such as a phone connection or an Internet connection. At a minimum, an alarm on the equipment used for temporary service shall be automatically sent to the Contractor's 24 hour monitoring service and to the Owners help desk. The Contractor shall respond to and be responsible for securing conditions within the building. Owner shall assess the situation and as necessary secure utilities feeding the building from isolation points outside of the building.
3. Campus Utility Impact: The Temporary Conditioning Plan shall address the expected impact on the campus utilities involved in the temporary conditioning equipment. Specifically address:
    a. How the systems will be controlled to both ensure they are operating in range, and to avoid energy waste or inefficient conditions;
    b. Project the range of loads and flows to be imposed on the campus systems. For cooling, indicated how you will ensure a temperature split of at least 12°F.
    c. For campus chilled water connections, the bridge connection and automatic control of the bridge-related sequences shall be installed, functional and tested.

4. Building Protection: Address how the system will be controlled to avoid humidity conditions that could either promote mold growth or cause corrosion.
5. Equipment Reconditioning: Address with specific means and methods how the equipment used for temporary conditioning will be reconditioned to like-new condition. Belts, seals, bearings, couplings, or other parts that wear more than 3% of their expected life shall be replaced.
6. Cleaning: Address how ducts, pipes, coils, converters, air handling equipment, terminal units, etc. shall be cleaned prior to Turn-Over.
7. Operations Log: Contractor responsible for operating the equipment shall maintain a log of all activities associated with operating and maintaining equipment. Log shall be submitted to Owner on a frequency specified by the Owner.
8. Operating System Alterations: The Temporary Conditioning Plan shall address specific protocol for doing work on the systems.
9. Damages: Any material, device, component, or equipment that is assessed as damaged or as having a substantially shortened life as a result of temporary conditioning operation shall be replaced by the Contractor at no cost to the Owner or to the project.
10. Segregation: Where only portions of a system are to be used, Contractor shall specifically indicate how the used portion will be isolated from the unused portion. The Temporary Conditioning Plan shall address how to ensure that the reduced operation condition will be maintained within acceptable ranges, and/or how capacity will be throttled to keep all operating parameters in recommended ranges.

1.17 TRAINING EVENTS AND TRAINING PLAN

A. Contractors, subcontractor, vendors, and other applicable Parties shall prepare and conduct training sessions on the installed systems and equipment they are responsible for per the requirements of Section 01 91 00 and the individual Specifications.

1.18 SYSTEMS MANUAL AND O&M DOCUMENTATION CONTENT - PREPARATION AND LOGISTICS

A. Refer to Section 01 91 00 the individual Specifications.

1.19 BAS TRENDING REQUIREMENTS

A. Trending requirements are as specified in Section 01 91 00 and Section 230801

B. The BAS Contractor shall configure and analyze all trends required under Section 230801.

C. Trends are historical archives on computer disks that document the operation of the systems and equipment. Trends can be time-series (interval) recordings of system I/O parameters or change-of-value (COV) based trends that record when a system value changes by more than a specified threshold.

D. CxA will analyze trend logs of the system operating parameters to evaluate normal system functionality. The requirements of the trending are specified below. Contractor shall establish

these trends, ensure they are being stored properly, and forward the data in electronic format to the CxA.

E. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field. Recorded parameters for a given piece of equipment or component shall be trended at the same time intervals and be presented in a maximum of two separate two dimensional formats with time being the vertical axis and field name being the horizontal axis.. Data shall be forwarded in one of the following formats.

1. Microsoft Access Database (.mdb)
2. Microsoft Excel Spreadsheet (.xls)
3. Comma Separated Value (.csv or .txt), preferably with quotes delimiting text fields and # delimiting date/time fields.

F. Sample times indicated as COV (±) mean that the changed parameter only needs to be recorded whenever the value changes by the amount listed. When output to the trend file, the latest recorded value shall be listed along with the time increment record. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the time interval common to other point trends for the system.

G. Contractor shall provide the CxA with required passwords, phone numbers, etc. to allow the CxA access to the trend log data and allow downloading to a remote location. Contractor shall also provide step-by-step written instructions for accessing the data.

1.20 FUNCTIONAL PERFORMANCE TESTING

A. Contractor shall participate in the initial samples of Functional Performance Testing as stipulated in Section 01 91 00 and Section 01 91 10.

1.21 FPT ACCEPTANCE CRITERIA

A. Acceptance criteria for tests are indicated in Section 01 91 10 and in the specification Sections applicable to the systems being tested. Unless indicated otherwise, the criteria for acceptance will typically be that specified with the individual system, equipment, component, or device.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

A. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:

B. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of +/- 0.1°F.

C. Pressure sensors shall have an accuracy of +/- 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

D. All equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.

E. Standard Testing Instrumentation: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems related to functional testing shall be provided by CxA.

F. Special Tools: Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and turned over to the Owner upon project completion.

2.2 WEB-BASED COMMISSIONING PORTAL

A. All general and major subcontractors participating in the Cx process shall use the web-based Cx Portal ('Portal') to document the Cx procedures. The Portal is a Web-based Internet hub used to electronically collaborate and coordinate activities and deliverables throughout the Cx process. The Portal is hosted by the CxA and shall be accessible to all Parties participating in the Cx program. The Portal provides a common location to store Start-Up Documentation, Functional Performance Tests and results, project documents and deliverables. It also serves as a collaborative email hub to facilitate, automate, and track communications between Parties relating to the Cx process.

B. Refer to Section 01 91 00 the individual Specifications for additional information and requirements for using the Portal.

PART 3 - EXECUTION

3.1 GENERIC START-UP DOCUMENTATION - GENERAL

A. Part III of this Section outlines 'generic' or minimally acceptable Start-Up Documentation (which are defined to include both 'Start-Up Checks' and 'Start-Up Tests') and individual systems training requirements for systems and equipment. These procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct per normal quality control practices. These items shall provide a minimally acceptable guideline for required Contractor development of Start-Up Documentation. Contractor shall synthesize these minimum requirements along with their own internal quality control practices, those of the manufacturer, and any applicable codes and standards to develop specific and itemized final Start-Up Documentation specific to the equipment and systems installed on this project.

B. Section 01 91 00 defines the systems and equipment Start-Up process in detail and provides definitions for Start-Up Documentation, including the generic Start-Up Documentation provided below.

3.2 START-UP DOCUMENTION COMMON TO ALL SYSTEMS

A. The following Start-Up Documentation (Checklists and Tests) shall be considered common to all systems:

1. Checkout shall proceed from lower level devices to larger components to the entire system operation.
2. Verify labeling is affixed per specification and visible.
3. Verify prerequisite procedures are done.
4. Inspect for damage and ensure none is present.
5. Verify system is installed per the manufacturer’s recommendations.
6. Verify system has undergone Start-Up per the manufacturer’s recommendations.
7. Verify that access is provided for inspection, operation and repair.
8. Verify that access is provided for eventual replacement of the equipment.
9. Verify that record drawings, submittal data and O&M documentation accurately reflect the installed systems.
10. Verify all gauges and test ports are provided as required by contract documents and manufacturer’s recommendations.
11. Verify all recorded nameplate data is accurate.
12. Verify that the installation ensures safe operation and maintenance.
13. Verify specified replacement material/attic stock has been provided as required by the Contract Documents.
14. Verify all rotating and moving parts are properly lubricated.
15. Verify all monitoring and ensure all alarms are active and set per Owner’s requirements.
16. Complete all nameplate data and confirm that ratings conform to the design documents.

3.3 VALVES

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's instructions:

1. Operate all valves, manual and automatic, through their full stroke. Ensure smooth operation through full stroke and appropriate sealing or shutoff.
2. Verify actuators are properly installed with adequate clearance.
3. Verify all valves are labeled per the construction documents. Confirm that concealed valves are indicated on the finished building surface.
4. For automatic pneumatically-operated valves, verify spring range and adjust pilot positioners where applicable.
5. For electronically operated valves, check the stroke and range.

6. For all automated valves controlled by a program, ensure that the minimum and maximum stroke and ranges on the valves are coordinated with the limits entered in the program.

3.4 METERS AND GAUGES

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's instructions:

1. Adjust faces of meters and gauges to proper angle for best visibility.

2. Clean windows of meters and gauges and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint.

3. For meters and gauges requiring temporary manual connection of read-out device such as pressure taps on a flow measuring device, ensure threads are clean and that connection can be made easily.

4. Meters and gauges requiring manual connection of readout device shall be installed with adequate access to allow connection of device with normal tools.

3.5 MECHANICAL IDENTIFICATION

A. Start-Up Checks: Perform the following checks:

1. Verify all valve tags, piping, duct, and equipment labeling corresponds with drawings and indexes and meets requirements specified. Correct any deficiencies for all piping and duct systems.

2. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.

3. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.6 MECHANICAL INSULATION

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: Examine all piping, systems and equipment specified to be insulated.

1. Ensure quality of insulation. Patch and repair all insulation damaged after installation.

2. Ensure the integrity of vapor barrier around all cold surfaces.

3.7 PIPING - GENERAL

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: These procedures apply to all installed piping systems, including underground site utilities.

1. Inspect all piping for proper installation, adequate support (with appropriate vibration isolation where applicable) and adequate isolation valves for required service.
2. Submit welding certifications as required by the applicable specification section or referenced ASME specification.
3. Submit certified welding inspection results per the applicable specification section or referenced ASME specification. ASME B31.1 requires 100% inspection based on pressure class.
4. Provide notification of pipe cleaning and flushing activities.
5. Flush and clean all piping and clean all strainers. Provide documentation of all related procedures.
6. Ensure adequate drainage is provided at low points and venting is provided at high points.
7. Ensure facilities to effectively drain and fill the system are in place.
8. Ensure air is thoroughly removed from the system as applicable.
9. Ensure all piping is adequately supported and anchored to allow expansion. Bump across-the-line pumps and inspect for excessive pipe movement.
10. Provide notification of pressure testing.
11. Pressure and/or leak test all applicable systems in accordance with the requirements in the applicable sections, ASME B 31.1 and 39.1 as applicable.
12. Sterilize applicable piping systems as specified in the individual Sections and as required by regulatory authorities.
13. Submit pressure test reports that document the pressure testing results with certification of the results.
14. Verify the operation of applicable safety relief valves, operating controls, safety controls, etc. to ensure a safe installation.
15. Set and adjust fill, pressure, or level controls to the required setting.

3.8 AC MOTORS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's instructions:

1. Verify proper alignment, installation, and rotation.
2. Verify properly sized overloads are in place

C. Start-Up Tests: Perform the following tests, measurements, or procedures during start-up and as specified in manufacturer's instructions:

1. Measure insulation resistance, phase balance, and resistance to ground.
2. Measure voltage available to all phases. Measure amps and RPM after motor has been placed in operation and is under load.
3. Record all motor nameplate data.

3.9 BEARINGS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's instructions. This applies to all bearings on fans, pumps, compressors, and other equipment installed under this Division.

1. Check alignment as applicable.
2. Lubricate all bearings per the manufacturer’s instructions. When bearing is used for temporary conditioning, lubricate on manufacturer’s recommended frequency and document it.

C. Start-Up Tests: Perform the following tests, measurements, or procedures during start-up and as specified in manufacturer's instructions:

1. Use infrared thermometer to measure temperature at peak conditions. Ensure temperature is below manufacturer’s recommendations.
2. For bearings in drives with motors over 10 HP, use a vibration meter and measure the maximum peak-to-peak acceleration. Compare it to the Vibration Severity Chart. Rectify any condition causing severity indicated as “Rough” or worse.

3.10 VARIABLE SPEED DRIVES

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Provide the services of a factory authorized service representative to test and inspect unit installation, provide start-up service, and to demonstrate and train Owner's maintenance personnel as specified below.

C. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's instructions:

1. Check unit for shipping damage.
2. Perform a point-to-point continuity test for all field installed wiring interconnections. Verify terminations of field-installed wiring.
3. Check for proper torque on connections.

4. Verify use of shielded cable where specified and check that shields have been terminated properly.
5. Verify grounding.
6. Check motor nameplate against drive input rating.
7. Manually rotate motor shaft to ensure free rotation.
8. Check that motor leads are not grounded.

D. Start-Up Tests: Perform the following tests, measurements, or procedures during start-up and as specified in manufacturer's instructions. Ensure device and system which drive is serving is configured to withstand the device operation specified below.

1. Adjust the ‘Minimum Voltage Adjustment’ to enable starting but not to draw excessive power at start.
2. Adjust the ‘Volts/Hz Adjustment’ to proper setting.
3. Adjust the ‘Acceleration and Deceleration Rates’ to the specified times.
4. Adjust ‘Current Limiting’ to coordinate with the overcorrect device and protect the motor.
5. Set the ‘Maximum and Minimum Speed’ pots.
6. Manually ramp fan speed from minimum to maximum and check for excessive noise and vibration.
7. Determine any critical speeds to avoid and set these in the drive.
8. Check for acceptable voltage and current distortion on the power system. Record the input and output voltages and currents showing the harmonic content as a percentage of the base frequency.
9. Measure and record overall efficiency at 50%, 75%, and 100%.
10. Record the motor terminal voltage.

E. Training: Train Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance. Review data in manufacturer’s Operation and Maintenance Manuals.

3.11 HYDRONIC PIPING

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: Perform the following checks during start-up:

1. Prepare hydronic and test piping in accordance with applicable Section and ASME B 31.9 and/or B 31.1.
2. Flush system with clean water in accordance with applicable Section.
3. Clean strainers.

4. Check expansion tanks to determine that they are not air-bound and that the system is completely full of water.
5. Set automatic fill valves for required system pressure.
6. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
7. Set and coordinate automatic fill pressure and relief valve settings.

C. Start-Up Tests: Perform the following tests, measurements, or procedures during start-up:

1. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.12 STEAM AND CONDENSATE PIPING

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: Perform the following checks during start-up:

1. Prepare and test steam and condensate piping in accordance with applicable Section and ASME B 31.9 and or B31.1 as applicable.
2. Flush the system with clean water.
3. Remove, clean, and replace strainer screens.
4. Gradually warm-up piping and connected equipment. Introduce steam to piping system by throttling valves.
5. Take precautions to prevent water hammer or slugging in piping.
6. Vent air and non-condensable gases from system.
7. Supervise condensate removal at system traps. Temporarily, bypass traps if required.
8. Verify complete condensate removal from piping and equipment and that traps are functioning properly.

3.13 PUMPS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Refer to ‘AC Motors’ in this Section.

C. Refer to ‘Bearings’ in this Section.

D. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

E. Start-Up Checks: Perform the following checks during start-up:

1. Check suction lines connections for tightness to avoid drawing air into the pump.

2. Clean and lubricate all bearings.
3. Check motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
4. Check that pump is free to rotate by hand. For pumps handling hot liquids, pump shall be free to rotate with the pump hot and cold. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.
5. Clean associated strainers.
6. Check that the proper overloads have been installed in the starter and are the correct size.
7. Verify that the integrity of the vibration isolation is maintained throughout the support and the connections.
8. Align pump within manufacturers recommended tolerances.
9. Ensure all associated piping has been cleaned, tested, and deaerated.
10. Verify that all thermometers and gauges are installed, are clean and undamaged, and are functional.

F. Start-Up Tests: Perform the following tests, measurements, or procedures during start-up:

1. Start the pump per the manufacturer’s instructions.
2. Check the general mechanical operation of the pump and motor.
3. Verify that checkvalve seal is appropriate.
4. Check noise and vibration levels and ensure they are within the manufacturer’s recommended tolerances.
5. Check that the NPSH is with that allowable for the operating condition.
6. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

3.14 STEAM-TO-HOT WATER CONVERTERS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Refer to Division 23 Section "Testing, Adjusting, and Balancing".

C. Start-Up Checks: Perform the following checks during start-up:

1. Ensure converters are cleaned and flushed upon completion of installation in accordance with manufacturer's start-up instructions.

D. Start-Up Tests: Perform the following tests during start-up:

1. Hydrostatically test assembled converter and piping in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.
2. Start-up converters in accordance with manufacturer's start-up instructions.

3. Test controls and demonstrate compliance with requirements.
4. Replace damaged or malfunctioning controls and equipment.
5. Record all parameters (flow, temperatures, pressures, etc.) and tests and submit report.

3.15 STEAM CONDENSATE PUMPS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Start-up condensate pumping equipment in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements.

1. Refer to AC Motors.
2. Refer to Pumps.

3.16 PACKAGED HEATING AND COOLING UNITS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

C. Refer to AC Motors in this section.

D. Start-Up Checks: Perform the following inspections/checks during start-up:

1. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
2. Install new filters after start-up.

E. Training: Factory-authorized representative shall train Owner's maintenance personnel including:

1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.

3.17 ROOFTOP HEATING AND COOLING UNITS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

C. Refer to AC Motors in this section.

D. Start-Up Checks: Perform the following inspections/checks during start-up:

1. Ensure unit is level.
2. Coils are undamaged and fins are combed.
3. Condenser fan rotates freely and check rotation direction.

E. Start-Up Tests: Perform the following before or during start-up:

1. Start-up condensing units, in accordance with manufacturer's start-up instructions.
2. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
3. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.
4. Install new filters after start-up.

F. Training: Factory-authorized representative shall train Owner's maintenance personnel including:

1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.

3.18 TERMINAL UNITS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: Perform the following inspections/checks during start-up:

1. After construction is completed, including painting if applicable, clean unit exposed surfaces.
2. Vacuum-clean terminal coils and inside of cabinets.
3. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
4. Verify adequate access for maintenance.
5. Check power and control voltages.
6. Check rotation of fan where applicable.
7. Check calibration and operation of the controlling elements.
8. Check control valves for required close-off and fail position.
9. Install new filter units for terminals requiring same.

3.19 VAV TERMINAL UNITS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Refer to and coordinate with Division 23 Section "Testing, Adjusting, and Balancing".

C. Start-Up Checks: Perform the following inspections/checks during start-up:

1. After construction is completed, including painting if applicable, clean exposed unit surfaces.
2. Clean factory-finished surfaces. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
3. Ensure unit is properly supported and that integrity of vibration isolation has been maintained where applicable.
4. Ensure that air velocity sensor is correctly installed and that inlet/outlet restrictions for accurate measurements have been met.
5. Ensure air inlet is free of obstructions. Start fans and ensure proper rotation (as applicable). Measure and record motor amperage and voltage.
6. Ensure the coils are undamaged, combed, and vented.
7. Check the heating device and control to ensure functionality and proper installation. Check stroke and range on the valve and ensure it closes and seals tightly.

D. Start-Up Tests: Perform the following during start-up:

1. Calibrate and adjust the airflow control parameters. Set applicable min and max setpoints. Coordinate with the ATC contractor as necessary to obtain flow parameters required.
2. Install new filters where required.
3. Set all temperature and humidity setpoints to those as directed by Owner.
4. Record supply air temperature at full cooling and at full heating (compare both with current air handler temp)

3.20 CENTRAL-STATION AIR HANDLING UNITS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

C. References: The following additional Sections shall also apply:

1. Refer to AC Motors in this Section.
2. Refer to Fans in this Section.
3. Refer to Bearings in this Section.
4. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.
5. Refer to Division 23 Section “BAS Commissioning” for procedures for starting the controls related to the AHU.

D. Start-Up Checks: Perform the following inspections/checks during start-up:

1. Inspect the field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.
2. Cleaning: Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
3. Adjust and lubricate dampers and linkages for proper damper operation.
4. For field fabricated units, ensure the sections are properly connected within acceptable tolerances.
5. Seal all penetrations to be air-tight and ensure access doors seat tightly.
6. Verify that unit is secure on mountings and supporting devices and connections for piping, ductwork, and electrical are complete.
7. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
8. Ensure vibration isolation integrity is maintained throughout the AHU installation and its connections.
9. Tension all belts per the drive manufacturer’s recommendations.
10. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
11. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
12. Comb coil fins for parallel orientation.
13. Install clean filters.
14. Ensure condensate drains properly and that trap is adequate.
15. Stroke all valves and damper to ensure free and full travel.

E. Start-Up Tests: Perform the following during start-up:

1. Pressure test units as required in the AHU specification

F. Training: Factory-authorized representative shall train Owner's maintenance personnel including:

1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of manufacturer’s Operating and Maintenance Manuals.

3.21 FANS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

C. References: The following additional Sections shall also apply:

1. Refer to AC Motors in this Section.
2. Refer to Bearings in this Section
3. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.
4. Refer to Division 23 Section “BAS Commissioning” for procedures for starting the controls related to the AHU.

D. Start-Up Checks: Perform the following inspections/checks during start-up:

1. Inspect the field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.
2. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
3. Adjust and lubricate dampers and linkages for proper damper operation.
4. Verify that unit is secure on mountings and supporting devices and connections for ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
5. Ensure vibration isolation integrity is maintained with the fan installation and associated connections.
6. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
7. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
8. Stroke all dampers to ensure free and full travel.

E. Training: Contractor shall train Owner's maintenance personnel including:

1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of manufacturer’s Operating and Maintenance Manuals.

3.22 ENERGY RECOVERY VENTILATION SYSTEMS (WHEEL-BASED)

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Refer to AC Motors in this Section.

C. Refer to Fans in this Section (if applicable).

D. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

E. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's start-up instructions:

1. Check for damage to the ERV wheel and media and ensure media is evenly/thoroughly impregnated.
2. Ensure the ERV wheel rotates freely.
3. Ensure all drive components are correctly installed, aligned and lubricated.
4. Ensure air seals are tight and properly installed.
5. Verify all controls are in place and that they are properly interfaced.

F. Start-Up Tests: Follow the manufacturer's written procedures and the following as a minimum:

1. Energize circuits.
2. Check for proper rotation in all modes of operation.
3. Start and run ERV unit through complete sequence of operations.
4. Measure and record the sensible and latent recovery efficiency.
5. Measure and record air pressure drop.
6. Adjust operating controls.

G. Training: Factory-authorized representative shall train Owner's maintenance personnel including:

1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of manufacturer’s Operating and Maintenance Manuals.

3.23 AIR CLEANING AND FILTERS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Operate installed air filters to demonstrate compliance with requirements. Test for air leakage of unfiltered air while system is operating. Correct malfunctioning units at site, then retest to demonstrate compliance; otherwise remove and replace with new units, and proceed with re-testing.

3.24 METAL DUCTWORK

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure using polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

C. Start-Up Checks: Perform the following checks during start-up and as specified:

1. Clean ductwork internally of dust and debris, unit-by-unit as it is installed. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.

2. Strip protective paper from stainless ductwork surfaces if applicable, and repair finish wherever it has been damaged.

D. Start-Up Tests: In addition to specifications, perform the following as a minimum:

1. Leakage Tests: After each duct system which is constructed for duct classes over 2" is completed, test for duct leakage in accordance with the current SMACNA HVAC Air Duct Leakage Test Manual. Repair leaks and repeat tests until the leakage is less than the SMACNA allowed total for the section being tested.

2. Balancing: Refer to Division-23 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork; not work of this section. Seal any leaks in ductwork that become apparent in balancing process.

3.25 DUCTWORK ACCESSORIES

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: Perform the following checks during start-up and as specified:

1. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

C. Start-Up Tests: In addition to specifications, perform the following as a minimum:

1. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leak proof performance.

2. Label access doors in accordance with Division 23 Section "Mechanical Identification".

3. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.

4. Final positioning of manual dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing".

5. Fire Damper Testing: For every fire damper, remove the fusible link and verify that the damper operates freely and closes tightly. Reinstall the fusible link.

3.26 AIR TERMINALS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: Upon completion of installation and prior to initial operation, check that air terminals are:

1. Properly installed with the proper airflow direction.
2. Properly supported with vibration isolation integrity maintained where applicable.
3. Duct connections to air terminals are leak-tight.
4. Operable dampers travel free.
5. Airflow measuring devices are properly installed and connected.
6. Repair or replace air terminals and duct connections as required to eliminate leaks, and retest to demonstrate compliance.
7. Clean exposed factory-finished surfaces. Repair any marred or scratched surfaces with manufacturers touch-up paint.

3.27 BUILDING AUTOMATION AND CONTROL SYSTEMS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Start-Up Checks: Perform the following checks during start-up and as specified:

1. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

C. Start-Up Tests: Refer to Section 230801 “BAS Commissioning”. This requires manufacturers authorized representative to start-up, test, adjust, and calibrate direct digital and other microprocessor-based control systems and demonstrate compliance with requirements. This will include verification of sequences, normal and emergency operations, calibration, interfaces, and interlocks, etc.

3.28 TESTING, ADJUSTING, AND BALANCING

A. Reference: Perform testing, adjusting, and balancing (TAB) procedures on each system identified, in accordance with the detailed procedures outlined in the respective section and the referenced standards.

B. Start-Up Checks: In addition to specifications, perform the following as a minimum:

1. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
2. Patch insulation, ductwork, and housings, using materials identical to those removed.
3. Seal ducts and piping, and test for and repair leaks.
4. Seal insulation to re-establish integrity of the vapor barrier.

5. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
6. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.
7. Test and adjust mechanical systems for sound and vibration in accordance with the detailed instructions of the referenced standards.

C. Training:

1. Train the Owner's maintenance personnel on troubleshooting procedures and on testing, adjusting, and balancing procedures.
2. Review for the Owner’s personnel the locations of TAB reports and data.

3.29 ROOM/ZONE CHECKOUT

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Contractor shall complete a checklist acknowledging completion of Div. 23 responsibilities for all rooms. Checklist shall include items such as the following as applicable:

C. Typical Room:

1. Diffusers, registers, and grilles installed and cleaned.
2. Zone controls in place and functional.
3. All terminal equipment functional, clean, and punched out.
4. Occupancy schedules entered with applicable control setpoints.

D. Rooms with Plumbing Fixtures

1. Plumbing fixtures clean and operational.

3.30 SEQUENCING ILLUSTRATION

A. Reference Section 01 91 00.

END OF SECTION 23 08 00

SECTION 23 08 01
BUILDING AUTOMATION SYSTEM (BAS) COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes: The Work of this Section shall include but not be limited to the following:

1. BAS Start-Up and Functional Performance Testing.
2. Validation of proper and thorough installation of BAS and associated equipment.
3. Generic Start-Up Documentation for BAS.
4. Development of final Start-Up Documentation for BAS.
5. Functional Performance Testing of BAS.
6. Coordination of BAS-related training.
7. Documentation of BAS Operation and Maintenance Documentation.

B. Related Work and Documents

1. The Cx process references many related Sections, particularly Section 01 91 00 - General Commissioning. It is important for all Contractors subject to the Cx process to be familiar with Section 01 91 00.
2. Refer to Section 01 91 00 for a complete list of Sections on Related Work.

1.3 GENERAL DESCRIPTION

A. This section defines responsibilities of the Building Automation System Contractor to commission the BAS.

B. Commissioning (Cx) is the process of ensuring that (i) all building systems are installed and perform interactively according to the design intent; (ii) that systems are efficient and cost effective and meet the Owner's operational needs; (iii) that the installation is accurately documented; and (iv) that the Operators are adequately trained. Commissioning serves as a tool to minimize post-occupancy operational problems, and establishes testing and communication protocols to advance the building systems from installation to optimized, fully-dynamic operation.

C. Commissioning Authority (CxA) shall work with the Contractor and the design engineers to direct and oversee the Cx process and perform Functional Performance Testing.

D. The Commissioning Plan outlines the Cx process beyond the Construction Contract, including design phase activities and design team/owner responsibilities. The specification Sections dictate all requirements of the commissioning process relative to the construction contract. The Cx Plan

is not part of the construction contract, although it is available for reference at the request of the Contractor.

1.4 SCOPE

A. The scope of Commissioning on this project shall include the entire BAS system.

1.5 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 01 91 00 for a complete list of Definitions and Abbreviations.

B. POT (Portable Operators Terminal): Portable operator workstation (typically a laptop computer) that has BAS software loaded and the capability to access, program, and edit the BAS.

C. HHD (Hand-Held Device): Portable device (typically with limited functionality) that is used to access components of the BAS. May be a standard PDA or proprietary device/interface.

1.6 REFERENCE STANDARDS

A. Refer to Section 01 91 00 for a complete list of Reference Standards.

1.7 CONTRACTOR RESPONSIBILITIES

A. General responsibilities of the BAS Contractor (BAC) are specified in Section 01 91 00. The following indicate additional specific responsibilities of the BAS Contractor.

B. Assist CxA in verification and Functional Performance Testing. Assistance will typically include the following:

1. Establish trend logs of system operation as specified herein.

2. Manipulate systems and equipment to facilitate Functional Performance Testing as outlined in Section 01 91 10. Typically, this will only be for initial samples of like systems.

3. Provide POTs or operator workstations in locations convenient to testing activities as specified below.

4. Provide CxA with appropriate passwords, keys, and access to control panels and workstations.

5. Where control systems do not allow a test mode or the overriding of physical input values for testing, program an interim virtual point for all inputs that can be used to represent the point and be overridden for testing.

C. Provide a control technician to work at the direction of the CxA for software optimization assistance for a minimum of 16 hours during the Acceptance Phase of the project.

D. Controls Parameter Matrix: Contractor shall provide a form summarizing all setpoints and alarm parameters and alarming strategies for the Owner to complete. Organize a meeting to discuss the desired initial setpoints and alarm parameters. Contractor shall enter the requested setpoints and alarm parameters at completion of start-up and record the applicable settings in the Start-Up Documentation.

E. Final Systems Operation Training: The BAC shall train the Owner and Operators on whole-building operation and use of the BAS. This training shall focus primarily on BAS control of building systems and operation and its impact on building performance, and shall be conducted after Functional Completion. Additional information is provided in Section 01 91 00.

F. Compensate the Owner for any BAS Contractor site time incurred due to incompleteness of systems or equipment at time of Functional Performance Testing. All testing failures which require on-site time for retesting will be considered actual damages to the Owner. The contract sum shall be reduced by contract modification at a rate of $180 per worker-hour of on-site time necessary to retest failures. All parties under contract with the Owner who are affected by the retesting shall be included in the contract modification. Refer to Section 01 91 00 and 01 91 10 for more details.

1.8 SEQUENCING

A. Refer to Section 01 91 00.

B. The following list outlines the general sequence of events for Commissioning of the BAS.

1. Construction Phase:
    a. Collaborate on construction scheduling.
    b. Submit Product data and Shop Drawings, and receive approval.
    c. Meet with Cx Team to coordinate with all trades.
    d. Submit Control Logic Documentation, and receive approval.
    e. Begin BAS installation.
    f. Submit refinement of generic Start-Up Documents incorporating manufacture-specific start-up requirements accompanied by manufacturers pre-printed start-up forms for all equipment provided by the BAS Contractor
    g. Receive BAS Start-Up Documents approval from CxA.
    h. Submit Training Plan content.
    i. Receive approval of Training Plan content.
    j. Provide alarm list and receive approval.
    k. Provide sample graphics and receive approval.
    l. Complete BAS installation.
    m. Place systems under BAS control.
    n. Enter alarms as approved by Owner.
    o. Complete BAS graphics.
    p. Perform BAS system start up and complete Start-Up Documentation.
    q. Submit completed BAS Start-Up Documentation.
    r. Prepare and initiate trend log data storage and format trend graphs.
    s. Train Owner on BAS operation and maintenance.

t. Formal BAS System Turn-Over Meeting.

u. Submit commissioning BAS Software/Access and provide Level 5 (monitoring, point override/test, and setpoint adjustment) password access to Owner and CxA.

v. Receive BAS Start-Up Documentation approval and approval to schedule BAS demonstration of completeness.

w. Demonstrate systems to CxA and Owner.

x. Submit trend logs in format specified.

y. Receive FPT or BAS demonstration approval and approval to schedule Acceptance Phase.

2. Acceptance Phase

   a. Two-week BAS Observation Period to witness stable BAS operation.

   b. Receive Observation Period approval which enables start of Functional Performance Testing.

   c. CxA performs Functional Performance Testing and BAS Contractor participates in initial samples.

   d. Receive Functional Completion approval for the BAS.

3. Substantial Completion.

4. Warranty Phase

   a. Provide administrator access password access to Owner.

   b. Train Owner on final sequences and modes of operation (Final Systems Operation Training).

   c. Update Systems Manual content with any changes.

   d. Revise and re-submit record drawings and O&M manuals.

   e. Install framed control drawings.

   f. Final Completion.

   g. Opposite-season operational test and Functional Performance Testing.

   h. Receive opposite-season operational test and FPT approval.

   i. Revise and re-submit record drawings and O&M manuals.

   j. Update framed control drawings.

   k. Complete owner training.

   l. End of Warranty Period.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

A. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of +/- 0.1°F.

2. Pressure sensors shall have an accuracy of +/- 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

3. All equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.

B. Standard Testing Instrumentation: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems related to functional testing shall be provided by CxA.

C. Special Tools: Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and turned over to the Owner upon project completion.

2.2 WEB-BASED COMMISSIONING PORTAL

A. General: The Cx Portal ('Portal') is a Web-based Internet hub used to electronically collaborate and coordinate activities and deliverables throughout the Cx process. The Portal is hosted by the CxA and shall be accessible to all Parties participating in the Cx program. The Portal provides a common location to store Start-Up Documentation, Functional Performance Tests and results, project documents and deliverables. It also serves as a collaborative email hub to facilitate, automate, and track communications between Parties relating to the Cx process. The Portal uses a hierarchical object tree to represent building systems, components and devices. From this object tree, one can access associated information at and below the applicable level. All applicable elements of information are associated with the object tree. The Portal facilitates either completing information directly via the software or by printing forms to fill out in the field.

B. Participation: All general and major subcontractors participating in the Cx process shall participate in the use of the Portal to document the Cx procedures.

C. Requirements for Use: Options for accessing and interfacing with the Cx Portal are as follows:

1. Print, Test, and File: Using this approach, Contractors simply go online to the Portal using a web browser, print checklists and tests as needed, fill them out in the field, and enter the results back into the Portal database when completed.

2. Online in the Field: The applicable documents can be accessed and filled out live and online if the Contractor has the means to access the Internet while working in the field using a local Wi-Fi network or wireless air card.

3. Database Client: At the Contractor's option, the CxA can provide the Contractor with a software tool that will allow the Contractor to download electronic test database files from the Portal, work on the database files in the field electronically (but offline), and later synchronize their entries with the master database on the Portal.

D. Portal Training: Included in the contract are two Contractor training sessions given by the CxA (one scheduled near the Construction Phase Cx Kickoff Meeting and one scheduled prior to the first equipment Start-Up). Contractors shall send at least one representative to at least one training session. Each Contractor is entitled to two hours phone technical support beyond training sessions.

2.3 TAB & COMMISSIONING PORTABLE OPERATORS TERMINAL

A. Provide the CxA with all software, connection devices, licenses, passwords, etc. to facilitate connection to the BAS throughout the building. Provide a license to graphic software, and all operating software necessary for testing and configuration of all control elements at all levels. License may be a temporary license that will expire after the completion of the Warranty Period. Options include:

1. A laptop computer provided by BAS Contractor for dedicated use by the CxA throughout the Construction and Acceptance Phases. This would be turned over to the Owner at the end of the Acceptance Phase.

2. Browser access to the full graphic software: CxA will provide laptop, however BAS Contractor shall set up the laptop to successfully connect.

3. Licensed client software to be installed on CxA computer: BAS Contractor shall install the software and ensure it is functional.

4. Terminal Services session access to a graphic server with required CALs to allow use of all required software. BAS Contractor shall configure the CxA computer to connect to the terminal session.

B. Access to the BAS must be provided throughout the building as more fully defined as follows:

1. Full wireless connection to the graphic server throughout the building will be adequate.

2. Network connection for full access to the graphic server within 50' of any point in the building.

3. Exception to 1 and 2 above: An acceptable alternative to full building access to the graphic server relating to terminal controls shall be providing to the CxA the devices and software required to connect to local terminal controllers through a connection port in the space such as connection to a jack on the temperature sensor (basically what is required by TAB specified below). This does not apply to mechanical rooms as full graphic access is required in mechanical rooms.

C. Provide software required by TAB to calibrate all flow sensors. TAB will provide computer to be used as a portable operator's terminal. Any manufacturer specific hardware such as connection cables, converters, hand held devices, etc. shall be provided by the BAS Contractor.

D. Connections shall be provided local to the device being calibrated. For instance, for VAV boxes, connection of the operator's terminal shall be either at the sensor as well as at the box. Otherwise a wireless system shall be provided to facilitate this local functionality.

PART 3 - EXECUTION

3.1 BAS START-UP TESTING, ADJUSTING, CALIBRATION

A. BAS work and/or systems shall be fully functioning prior to Demonstration and Acceptance Phase. Contractor shall start, test, adjust, and calibrate all work and/or systems under this contract, as described below:

1. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
2. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
3. Verify integrity/safety of all electrical connections.
4. Coordinate with TAB Contractor to obtain and with CxA to fine tune control settings that are determined from balancing procedures. Record the following control settings as obtained from TAB Contractor, and note any TAB deficiencies in the BAS Start-Up Documentation:
    a. Optimum duct static pressure setpoints for VAV air handling units.
    b. Minimum outside air damper settings for air handling units.
    c. Optimum differential pressure setpoints for variable speed pumping systems.
    d. Calibration parameters for flow control devices such as VAV boxes and flow measuring stations. BAS Contractor shall provide hand held device as a minimum to the TAB and CxA to facilitate calibration. Connection for any given device shall be local to the device (i.e., at the VAV box or at the thermostat). HHD or POT shall allow querying and editing of parameters required for proper calibration and Start-Up.
    e. Calibration parameters for fume hoods.
5. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the BAS display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range). Record the measured value and displayed value for each device in the BAS Start-Up Documentation.
6. Check and set zero and span adjustments for all transducers and transmitters.
7. For dampers and valves:
    a. Check for adequate installation including free travel throughout range and adequate seal.
    b. Where control loops are sequenced, check for proper control without overlap
8. For actuators:

a. Check to insure that device seals tightly when the appropriate signal is applied to the operator.
b. Check for appropriate fail position, and that the stroke and range is as required and coordinated with the programmed ranges when it is operating under normal conditions.
c. For pneumatic operators, adjust the operator spring compression as required to achieve close off. If positioner or volume booster is installed on the operator, calibrate per manufacturer's procedure to achieve spring range indicated. Check split range positioners to verify proper operation. Record settings for each device.
d. Check the stroke and range under actual loading conditions and validate that they correlate with programmed values.
e. For sequenced electronic actuators, calibrate per manufacturer's instructions to required ranges.

9. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the OI display. Record the results for each device.
10. For outputs to reset other manufacturers devices (such as VSDs) and feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.
11. Verify proper sequences by using the approved Start-Up Documentation to record results. Verify proper sequence and operation of all specified functions.
12. Verify that all safety devices trip at appropriate conditions. Adjust setpoints accordingly.
13. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the BAS Start-Up Documentation. Except from a start-up, maximum allowable variance from setpoint for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any step-change (for which the system has the capability to respond) in the control loop, the following tolerances shall be maintained (exceptions noted):
    a. Duct air temperature: ±1°F
    b. Zone temperature: ±3°F within 3 minutes and control within ±2°F
    c. Chilled water temperatures: ±1°F
    d. Hot water temperatures: ±2°F
    e. Duct air pressure: ± 0.25" w.g.
    f. Water pressure: ±1 psid
    g. Duct relative humidity: ±3% when adding humidity
    h. Zone relative humidity: ±5% when adding humidity
    i. Terminal air flow control: ±5% of setpoint.
14. For communication interfaces and BAS control panels:

a. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the record drawings.
b. Ensure that terminations are safe, secure and labeled in accordance with the record drawings.
c. Check power supplies for proper voltage ranges and loading.
d. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
e. Check for adequate signal strength and acceptable bandwidth utilization on communication networks.
f. Check for stand-alone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
g. Ensure that all outputs and devices fail to their proper positions/states.
h. Ensure that buffered and/or volatile information is retained through power outage.
i. With all system and communications operating normally and all trends functioning, sample and record update/annunciation times for critical alarms fed from the panel to the Operator Interface.
j. Check for adequate grounding of all BAS panels and devices.
k. Run self diagnostic routines and ensure they are functional.
l. Check the memory allocation and loading to ensure adequate and excess capacity is available and that it will not affect control functionality.

15. Coordinate desired initial alarm strategies with Owner's Operators. Set all required alarms and document the initial settings in the Start-Up Documentation.
16. Coordinate all initial setpoints with Owner's Operators. Ensure those setpoints are active.
17. For Operator Interfaces:
    a. Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
    b. Output all specified BAS reports for review and approval.
    c. Verify that the alarm printing and logging is functional and per requirements.
    d. Verify that trend archiving to disk and provide a sample to the CxA for review.
    e. Verify alarm enunciation functionality. Time delay from actual occurrence to the time updated or enunciated on the screen. Ensure it is per the specified requirements.
    f. Verify that real time and historical trends are accessible and viewable in graph format.
    g. Verify that paging/dial out alarm annunciation is functional.
    h. Verify the functionality of remote OIs and that a robust connection can be established consistently.
    i. Verify that required third party software applications required with the bid are installed and are functional.

j. Demonstrate open protocol and custom third party interfaces reliably communicate and check response time.

k. Verify response times and screen update and refresh times are per the requirements.

l. Verify that all custom programs are editable from the OI. Check upload, download, back up and restore capabilities of system configuration information as well as custom programs.

m. Verify schedules are set up and working.

n. Verify Owner stipulated security and permissions is set up and functional.

o. In concert with the Building Power Outage test, validate that critical GUI installations are properly powered by UPS and emergency outlets to keep it functional during a power outage. Validate that the space has adequate lighting to manage the building in the event of an outage.

18. Start-up and check out control air compressors and air drying and filtering systems in accordance with the appropriate section and with manufacturer's instructions.

a. Validate adequate deliver and pressures

b. Validate adequate redundancy

c. Validate max run time and cycle time vs manufacturer's recommendations

d. Validate that routing of the compressed air does not result in condensation at any point in the system when used with the specified drier

e. Check all PRVs both primary and back up to ensure adequate functionality and maintenance of downstream pressure

19. Verify proper interface with Fire Alarm System.

20. Verify proper interface with control panels of equipment with self-contained controls that are being monitored by the BAS.

B. Submit Start-Up Documentation. This shall be completed, submitted, and approved prior to demonstration and Acceptance Phase.

3.2 SENSOR CHECKOUT AND CALIBRATION

A. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading of each other for pressure. Tolerances for critical applications may be tighter.

B. Calibration: Calibrate all sensors using one of the following procedures:

1. Sensors Without Transmitters--Standard Application. Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gage or BAS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors

are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20% of the expected range.

2. Sensors With Transmitters--Standard Application. Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or BAS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

C. Sensor Tolerance: Sensors shall be within the tolerances specified for the device. Refer to Section 23 09 00

3.3 LOOP TUNING

A. For all control loops, Contractor shall tune the loops to ensure the fastest stable response without hunting, offset or overshoot with tolerances defined above. Contractor shall introduce upsets to the load when possible to affect response. Otherwise, setpoints can be changed to affect the response.

B. Generally tune loops during periods of high gain.

C. Document all parameters either by capturing text, short interval trends, or screen shots of trend graph documenting the final response.

3.4 COIL VALVE LEAK CHECK

A. Verify proper close off of the valves. Ensure the valve seats properly by simulating the maximum anticipated pressure difference across the circuit. Calibrate air temperature sensors on each side of coil to be within 0.5°F of each other. Via the OI, command the valve to close. Energize fans. After 5 minutes, observe air temperature difference across coil. If a temperature difference is indicated, and the piping surface temperature entering the coil is within 3°F of the water supply temp, leakage is probably occurring. If it appears that it is occurring, close the isolation valves to the coil to ensure the conditions change. If they do, this validates the valve is not closing. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing the seat, or replacing the valve as applicable.

3.5 VALVE STROKE SETUP AND CHECK

A. For all valve and actuator positions checked, verify the actual position against the OI readout.

B. Set pumps to normal operating mode. Command valve closed, verify that valve is closed, and adjust output zero signal as required. Command valve open, verify position is full open and adjust output signal as required. Command valve to a few intermediate positions. If actual valve position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics)

3.6 ALARM SETPOINT COORDINATION

A. The Contractor shall prepare a list of all conceptual point types and recommend the types and recommended alarming strategies and setpoint for review of CxA and Owner. Owner shall use this alarm list to provide direction to Contractor for alarm strategies and setpoints. Alarm list shall be provided at least two months prior to the first functional test. Contractor shall have alarm setpoints entered prior to functional testing. Omitting an alarm setting, using the wrong strategy, or entering the wrong setpoints will be considered a failure from the perspective of the functional test.

3.7 GRAPHIC COORDINATION

A. The Contractor shall prepare all graphics (only one example graphic is required for typical systems like terminal units) with points embedded for review of CxA and Owner. Owner shall use these graphics to provide direction to Contractor for the required final graphic. All final graphics must be complete and active before functional testing. Any deviation from the approved graphics will be considered a failure from the perspective of the functional test.

3.8 BAS DEMONSTRATION

A. Demonstrate the operation of the BAS hardware, software, and all related components and systems to the satisfaction of the CxA and Owner. Schedule the demonstration with the Owner's representative 1 week in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report are approved. If the Work fails to be demonstrated to conform with Contract specifications, so as to require scheduling of additional site visits by the CxA for re-demonstration, Contractor shall reimburse Owner for costs of subsequent CxA site visits.

B. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the job site.

C. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner and CxA.

D. The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved Commissioning Checklists. Demonstration shall include, but not necessarily be limited to, the following:

1. Demonstrate that required software is installed on BAS workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
2. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.
3. Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.
4. Demonstrate correct calibration of input/output devices using the same methods specified for the start-Up tests. A maximum of 10 percent of I/O points shall be selected at random by

CxA and/or Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by CxA for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.

5. Demonstrate that all BAS and other software programs exist at respective field panels. The BAS programming and point database shall be as submitted and approved.
6. Demonstrate that all BAS programs accomplish the specified sequences of operation.
7. Demonstrate that the panels automatically recover from power failures, as specified.
8. Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
9. Identify access to equipment selected by CxA. Demonstrate that access is sufficient to perform required maintenance.
10. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.

E. BAS Demonstration shall be completed and approved prior to Functional Performance Testing. CxA shall determine if the system is ready for Functional Performance Testing and document any problems requiring Contractor attention.

1. If the systems are not ready for Functional Performance Testing, Contractor shall correct problems and provide notification to the Owner’s representative that all problems have been corrected. The Acceptance Period shall be restarted at a mutually scheduled time for an additional one week period. This process shall be repeated until CxA issues notice that the BAS is ready for Functional Performance Testing.

F. Any tests successfully completed during the BAS Demonstration will be recorded as ‘Passed’ for the Functional Performance Testing and will not have to be re-accomplished.

3.9 FUNCTIONAL PERFORMANCE TESTING

A. Requirements for assistance with Functional Performance Testing are specified in the Section 01 91 00, Section 23 08 00 and Section 26 08 00. Provide assistance during Functional Performance Testing per the Section 01 91 00 and related Specifications.

3.10 BAS ACCEPTANCE PHASE AND OBSERVATION PERIOD

A. BAS Acceptance Phase: BAS Acceptance Phase consists of the Functional Performance Testing process of the BAS by the CxA and shall begin after approval of the BAS Demonstration and prior to issuance of Substantial Completion. Acceptance Phase for the BAS shall not be scheduled until all HVAC systems are in operation, the Start-Up Documentation has been reviewed, all required cleaning and lubrication has been completed (i.e., filters changed, piping flushed, strainers cleaned, etc.), and TAB report has been submitted and approved.Acceptance Phase and its approval to begin will be performed on a system-by-system basis if mutually agreed upon by Contractor and Owner.

B. BAS Observation Period: After Functional Performance Testing, the BAS shall be shown to operate properly for 2 weeks without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. At the end of the two weeks, BAS Contractor shall forward the trend logs to the CxA for review.

C. During the Acceptance Phase, the Contractor shall maintain a hard copy log of all alarms generated by the BAS. For each alarm received, Contractor shall diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the Contractor's opinion, the cause of the alarm is not the responsibility of the Contractor, Contractor shall immediately notify the Owner's representative.

D. During the Acceptance Phase, the Contractor shall maintain all controller network and workstation hardware and software in a state that will allow remote access by CxA to trend logs as specified below.

3.11 BAS TREND REQUIREMENTS

A. The BAS Contractor shall configure and analyze all trends required under this section

B. Trends are historical archives on computer disks that document the operation of the systems and equipment. Trends can be time-series (interval) recordings of system I/O parameters or change-of-value (COV) based trends that record when a system value changes by more than a specified threshold.

C. CxA will analyze trend logs of the system operating parameters to evaluate normal system functionality. The requirements of the trending are specified below. Contractor shall establish these trends, ensure they are being stored properly, and forward the data in electronic format to the CxA.

D. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field. Recorded parameters for a given piece of equipment or component shall be trended at the same time intervals and be presented in a maximum of two separate two dimensional formats with time being the vertical axis and field name being the horizontal axis.. Data shall be forwarded in one of the following formats.

1. Microsoft Access Database (.mdb)
2. Microsoft Excel Spreadsheet (.xls)
3. Comma Separated Value (.csv or .txt), preferably with quotes delimiting text fields and # delimiting date/time fields.

E. Sample times indicated as COV (±) mean that the changed parameter only needs to be recorded whenever the value changes by the amount listed. When output to the trend file, the latest recorded value shall be listed along with the time increment record. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the time interval common to other point trends for the system.

F. Contractor shall provide the CxA with required passwords, phone numbers, etc. to allow the CxA access to the trend log data and allow downloading to a remote location. Contractor shall also provide step-by-step written instructions for accessing the data.

G. Trending Requirements: All I/O points on primary equipment shall be trended throughout the Cx process on 10 min. intervals for analog values and change-of-value for binary values. Trends shall include but are not necessarily limited to the following points:

1. Outside air temperature
2. Outside air relative humidity
3. Outside air enthalpy
4. Cooling tons
5. All sensed hydronic temperatures
6. All sensed air temperatures and relative humidity measurements on primary equipment
7. All damper outputs on primary equipment
8. All valve outputs on primary equipment
9. All sensed fan volumes (flow) on primary equipment
10. All inputs and outputs to VSDs
11. Return (or exhaust) air temperature on each air handler
12. All safety indications
13. Status on all primary equipment
14. All air and water pressures on primary equipment or systems
15. Zone temperatures
16. Steam flow
17. Electricity consumption where monitored.
18. Natural gas flows
19. Converter steam valves and hot water temperatures
20. Steam supply pressures and temperatures.
21. Basically all points on primary equipment and selected sampling of terminal points unless approved otherwise

H. Trending used to document ongoing FPTs may occur be at a more frequent interval. Consult with the CxA to determine the required intervals for functional testing and modify intervals as required.

3.12 TREND GRAPHS

A. Trend graphs shall be used during Functional Performance Testing to facilitate and document testing. Contractor shall prepare controller and workstation software to display graphical format

trends throughout the Acceptance Phase. Trend graphs shall demonstrate compliance with contract documents. Trended values and intervals shall be the same as those specified for the Functional Performance Tests.

B. Lines shall be labeled and shall be distinguishable from each other by using either different line types or different line colors.

C. Indicate engineering units of the y-axis values; e.g. degrees F., inches w.c., Btu/lb, percent wide open, etc.

D. The y-axis scale shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.

E. Trend outside air temperature, humidity, and enthalpy during each period in which any other points are trended.

F. All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended simultaneously and on a common trend period.

G. Each graph shall be clearly labeled with HVAC subsystem title, date, and times.

3.13 WARRANTY PHASE - OPPOSITE SEASON TRENDING AND TESTING

A. Trending: Throughout the Warranty Phase, trend logs shall be maintained as required for the Acceptance Phase. BAS Contractor shall forward archived trend logs to the CxA for review upon CxA request. CxA will review these and notify BAS Contractor of any warranty work required.

B. Opposite Season Testing: Within 6 months of completion of the Acceptance Phase, CxA shall schedule and conduct Opposite Season Functional Performance Testing. The BAS Contractor shall support this testing and remedy any deficiencies identified.

3.14 SOFTWARE OPTIMIZATION ASSISTANCE

A. The Contractor shall provide the services of a BAS technician as specified above at the project site to be at the disposal of the CxA. The purpose of this requirement is to make changes, enhancements and additions to control unit and/or workstation software that have been identified by the CxA during the construction and commissioning of the project and that are beyond the specified Contract requirements. The cost for this service shall be included with the bid. Requests for assistance shall be for contiguous or non-contiguous 8-hour days, unless otherwise mutually agreed upon by Contractor, CxA, and Owner. The Owner’s representative shall notify Contractor 2 days in advance of each day of requested assistance.

B. The BAS technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the BAS technician provided cannot perform every software task requested by the CxA in a timely fashion, Contractor shall provide additional qualified personnel at the project site as requested by the CxA to meet the total specified requirement on-site.

3.15 BAS OPERATOR TRAINING

A. Provide up to 6 complete sets of User Manuals (hard copy and one electronic copy) to be used for training.

B. BAS Contractor shall submit a Training Plan per the requirements of Div 01 to the GC who will forward it to the A/E and CxA for review.

C. On Site Training: Provide services of BAS Contractor's qualified technical personnel for five 8-hour days to instruct Owners personnel in operation and maintenance of the BAS. Instruction shall be in classroom setting at the project site for appropriate portions of the training. Training may be in non-contiguous days at the request of the Owner. The Owner's representative shall notify Contractor 1-week in advance of each day of requested training. The Contractor's designated training personnel shall meet with the A/E, CxA and Owner's representative for the purpose of discussing and fine-tuning the training agenda prior to the first training session. Training agenda shall be as follows:

1. Basic Operator Workstation Training – 8 hours for all potential users of the OWS in 4-hour non-contiguous segments:
    a. Brief walk-through of building, including identification of all controlled equipment and condensed demonstration of controller portable and built-in operator interface device display capabilities.
    b. Brief overview of the various parts of the BAS O&M manuals, including hardware and software programming and operating publications, catalog data, controls installation drawings, and BAS programming documentation.
    c. Demonstration of workstation login/logout procedures, password setup, and exception reporting.
    d. Demonstration of workstation menu penetration and broad overview of the various workstation features.
    e. Overview of systems installed.
    f. Present all site-specific naming conventions and points lists, open protocol information, configuration databases, back up sequences, upload/download procedures, etc.
    g. Overview of scheduling procedures.
    h. Overview of alarm features, including how to acknowledge, respond to, and archive alarms, and how to access further information from them.
    i. Overview of trend features, including how to set up and view trends.
    j. Overview of workstation reporting features and introductory level report generation and scheduling.
2. BAS Technician Training: One24-hour training sessions that can be in 4-hour non-contiguous segments for individuals who will troubleshoot the system hardware, I/O devices, and the systems in general.
    a. General review of sequence of operation and control logic for the project site, including standalone and fail safe modes of operation;
    b. Uploading/downloading and backing up controller configuration and application programs;
    c. Review of installed components including all communication devices, controllers, I/O, etc., and how to install/replace, maintain, commission, and diagnose them;

d. Introduction to controller programming and overview of the programming application interface;

e. Defining trends, generating graphs in real time; archiving trends, accessing historical archive and generating reports from them;

f. Introductory network administration;

g. Introduction to creating and editing graphics;

h. Review of setpoint optimization and fine-tuning concepts;

i. OI use and maintenance;

j. Web page creation as applicable.

3. System Administrator Training: One 8-hour session that may be done in two 4-hour segments on non-contiguous days. Target audience is the person who will be maintaining the system from an IT perspective as well as Owners IT personnel. Agenda shall be as follows:

   a. Overview of system architecture including all routers, bridges, repeaters, gateways, communications protocols, servers, controllers, etc.;

   b. Overview of and recommendations for backing up and restoring the system configuration database;

   c. Server maintenance;

   d. Security Management: Assigning passwords and rights for various users on the server, workstations and GUI software.

4. Final Systems Operation Training

   a. The BAS Contractor shall conduct Final Systems Operation Training in accordance with Section 01 91 00.

   b. Final Systems Operation Training provides the Owner and Operators a training session on whole-building operation. It shall focus primarily on BAS control of building systems and operation and its impact on building performance. System interactions shall be presented and discussed (such as a combined air handler, chiller, boiler, and terminal unit system), along with a detailed presentation of the sequences of operation and their relationship to the BAS. This training shall be conducted by the BAC with assistance from the CxA, and shall be attended by the Owner, Operators, Contractor, Design Team, and by any other Cx Team members deemed necessary by the CxA or the Owner.

   c. The Record BAS Shop Drawings shall be provided as a handout for the training.

   d. Scheduling, attendees, and training methods shall be as specified in Section 01 91 00.

END OF SECTION 23 08 01

Section 23 09 23

DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Any deviations from the requirements of this standard must be submitted in writing to the engineer for approval.

B. In case there is a discrepancy between this specification and Division 21, Division 22, Division 23, Division 26 and Division 28 specifications and their associated drawings, then the Bidder shall assume the more stringent requirement for his bid.

1.2 RELATED DOCUMENTS

A. Refer to the mechanical drawings for sequence of operations and system device requirements.

B. Section 230923.12 "Control Dampers" for control damper requirements.

C. Section 230923.13 "Energy Meters" for thermal and electric power energy meters that connect to DDC systems.

D. Section 230923.14 "Flow Instruments" for requirements of all flow measuring devices.

E. Section 230923.16 "Gas Instruments" for gas measurement, monitoring, and detection systems.

F. Section 230923.17 "Level Instruments" for liquid-level switches, sensors, and transmitters that connect to DDC systems.

G. Section 230923.18 "Leak Detection instruments" for leak detection instruments and transmitters that connect to DDC systems.

H. Section 230923.19 "Moisture Instruments" for requirements of all moisture sensors, switches, and transmitters.

I. Section 230923.21 "Motion Instruments" for requirements of all motion sensors, switches, and transmitters.

J. Section 230923.22 "Position Instruments" for limit switches that connect to DDC systems.

K. Section 230923.23 "Pressure Instruments" for requirements of all pressure sensors, switches, and transmitters.

L. Section 230923.24 "Speed Instruments" for requirements of all speed sensors, switches, and transmitters.

M. Section 230923.27 "Temperature Instruments" for requirements of all temperature sensors, switches, and transmitters.

N. Section 230923.33 "Vibration Instruments" for vibration instruments that connect to DDC systems.

O. Section 230923.43 "Weather Stations" for weather stations that connect to DDC systems.

P. Communications Cabling:

1. Section 260523 "Control-Voltage Electrical Power Cables" for balanced twisted pair communications cable.
2. Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted pair communications cable.
3. Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber communications cable.
4. Raceways:
    a. Section 260533 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.
    b. Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cabling and optical fiber cable.
5. Section 260553 "Identification for Electrical Systems" for identification requirements for electrical components.
6. Section 270553 "Identification for Communications Systems" for identification requirements for communications components.

1.3 SUMMARY

A. Section Includes:

1. DDC system for monitoring and controlling of HVAC systems.
2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

1.4 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.

2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.

3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.

4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.

5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. DOCSIS: Data-Over Cable Service Interface Specifications.

K. E/P: Voltage to pneumatic.

L. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

M. HLC: Heavy load conditions.

N. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

O. I/P: Current to pneumatic.

P. LAN: Local area network.

Q. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

R. Modbus TCP/IP: An open protocol for exchange of process data.

S. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

T. MTBF: Mean time between failures.

U. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

V. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

W. PDA: Personal digital assistant.

X. Peer to Peer: Networking architecture that treats all network stations as equal partners.

Y. POT: Portable operator's terminal.

Z. PUE: Performance usage effectiveness.

AA. RAM: Random access memory.

BB. RF: Radio frequency.

CC. Router: Device connecting two or more networks at network layer.

DD. Server: Computer used to maintain system configuration, historical and programming database.

EE. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

FF. UPS: Uninterruptible power supply.

GG. USB: Universal Serial Bus.

HH. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

II. VAV: Variable air volume.

JJ. WLED: White light emitting diode.

1.5 SCOPE OF WORK

A. Control Contractor shall:

1. Provide installations of controllers and instruments provided by system and device manufacturers for equipment monitoring and control as shown in contract documents, and as herein specified. The scope shall include controllers, microprocessor-based controller unit panels, instrumentation, end control devices, wiring, conduit, and all ancillary devices required to achieve the specified sequence of operations.

2. Provide the required DDC control system hardware along with sensing devices, control valves, dampers and actuators as specified herein.

3. Provide a complete operational system including all work specified herein, specified in associated specifications for mechanical and electrical work, and shown on all contract drawings.

4. The Contractor shall assume all control points referred to in this specification as well as the specifications in Division 23 and Division 26. The contractor is also responsible for all instrumentation and controls shown on the controls drawings, Division 23 and Division 26 drawings.

5. The BAS system shall provide equipment supervision and control, alarm management, energy management, information management, historical data collection and archiving and be capable of integrating multiple building functions.

6. The system shall employ standard networking practices and conventions, co-exist with existing Ethernet networks, and manage system data using generally accepted database storage and retrieval methods and standards.

7. Provide all wiring, raceways and electrical work associated with the BAS. This shall include and to be limited to the following:

   a. Controls wiring and conduit between control panels.

   b. Controls wiring and conduit between control panels and field instrumentation, external equipment control systems

   c. Wiring and conduit for the BAS communication networks.

8. Provide all electrical work associated with the BAS.

9. Provide all wiring in accordance with the latest editions of the local electrical code and the NEC.

10. Divisions 26 to provide dedicated circuits as required, refer to Division 26 drawings for junction box locations. Controls contractor to provide transformers and field terminations.

11. Incorporate surge transient protection into the design of the system to protect the electrical components in all DDC controllers, TECs, panels and workstations.

12. Install all DDC controllers with spare hardware capacity for future additions of at least 15% of each type of point and 25% spare memory capacity for future connection.

13. Miscellaneous control wiring of equipment not provided by the controls manufacturer is by others.

14. Provide current sensors appropriate for all remote starter enclosures and variable frequency drives. All current sensors shall be analog output type to display range of current. Current switches are not acceptable.

15. Provide control power transformers for valve actuators, damper actuators and all instruments and devices provided under this contract for low voltage operation.

16. Provide all wells for water monitoring devices, temperature sensors, flow switches and alarms, as required.

17. Furnish control dampers not integral to the factory assembled air handling units. Furnish dampers, meeting or exceeding the specifications, listed in the associated sections and located as shown on drawings. Coordination is required with Division 23, regarding the installation, final sizing and method of fixing and delivery of the dampers

18. Provide system graphics for each system. Provide scaled floor plans (Auto Cad) indicating equipment location, service, and system data as required by the Owner. Graphics to incorporate integrated points communicated via BAS. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BAS. The graphical interface shall be completely consistent with the existing head end system. All graphic samples must be submitted to owner for review.

19. Provide system graphical interface for adjustment of all setpoints defined in the sequence of operations, it is unacceptable to require modification of programming statements to adjust these values.

20. The controls contractor shall provide all programming and controls for the lighting system. Each lighting control device will be integrated on a room by room basis via a dedicated interface device.

21. Provide system graphical interface for all points shown in controls drawings, with full override capability from the graphics screen.

a. Provide at a minimum through the Tridium graphical interface the options for:

1) Auto (normal programmed state)

2) Time based override

3) Set (indefinite override)

22. All graphics to include dynamic screen link points for the following as a minimum;

a. Manufacturer cut sheets files, either in PDF or other file format for instrumentation and control device represented. All cut sheets to be provided with selection of model provided clearly identified by markings.

b. Sequence of operations as editable text file for the systems and devices represented.

c. Control system As-Builts

d. Testing and Balancing reports

e. Energy management dashboard for associated device (if applicable, refer to sequence of operations)

23. Provide engineering and shop drawings as specified herein.

24. Provide field supervision of the associated elements of work as specified herein.

25. Provide mechanical installation of all control instrumentation etc. as specified herein.

26. Provide testing, calibration and commissioning as specified herein.

27. Provide demonstration of operation and system performance testing as specified herein.

28. Provide as-built drawings as specified herein.

29. Provide Operation and Maintenance manuals as specified herein.

30. Provide Personnel Training as specified herein.

31. Provide attendance and support during the commissioning of the project to Divisions 23 and 26, as required by the coordinated commissioning program.

32. With commencement of the project provide test procedure documents (TPD) describing the testing of all interfaces between the BAS and other systems for approval by the Owner, the Engineer and the Management Contractor.

33. Installation of access doors is not provided by this section, however, the controls manufacturer shall furnish access doors as required, for equipment provided and installed by this section.

34. The Contractor shall coordinate all point and object naming conventions with the owner before start of work. Unless otherwise indicated by the owner, all point naming conventions shall adhere to tags set out by project haystack guidelines.

35. Integration with Third-party Manufacturer's Equipment

    a. The BAS shall be capable of interoperating with multiple building systems supplied by different manufacturers. The BAS shall be able to receive, react to, and return information from multiple building systems

        1) Point inputs and outputs from third-party controllers shall have real-time interoperability with BAS software features such as: Control, Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis.

        2) Third party HVAC controllers shall be kept to an absolute minimum on the project. No 3rd party application controllers can be utilized without written permission from the owner. The following exceptions will utilize 3rd party control systems, completely integrated with the BAS via Bacnet IP.

            a) Chiller and Boiler controllers

            b) BTU and Steam meters

            c) VFD's

            d) Dx cooling units

36. The contractor shall provide a remote access account via web browser to the design and commissioning team before acceptance testing commences. Account shall have full read access, including access to BAS code, and full point history access. Account shall remain active until all closeout procedures have been finished.

37. The contractor shall facilitate factory testing of programming in advance of shipment of any of the controllers to site. The factory shall have the ability to fully simulate and modify all inputs (both digital and analog) in order to simulate real installed conditions. Testing procedures for the factory programming shall be developed by the commissioning authority and shall reflect the procedures used during final functional performance testing. The following samples are required to be factory tested for proper programming:

    a. VAV w/reheat

    b. 4-pipe fan coil unit

    c. AHU

    d. Chilled Water System

    e. Hot Water System

1.6 RELATED WORK

A. Related Documents and Sections: Examine Contract Documents for requirements that directly affect or are affected by Work of this Section. A list of those Documents and Sections include, but is not limited to the following:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 01 General Requirements Specification Sections, apply to this Section.

2. Other Related Sections:

a. All Division 21 Equipment Sections

b. All Division 22 Equipment Sections

c. All Division 23 Equipment Sections

d. All Division 25 Equipment Sections

e. All Division 26 Equipment Sections

f. All Division 28 Equipment Sections

1.7 COORDINATION

A. Coordinate work under provisions of Division 1 and Section 230500 as applicable.

B. Ensure installation of components is complementary to installation of similar components in other systems.

C. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

D. Coordinate with the Owners IT department for locations of network controllers, communications cabling, and TCP/IP addresses.

E. Ensure system is completed and commissioned.

F. Division 23 - BAS Contractor shall be responsible for all electrical work associated with the BAS control system as detailed below.

1. Perform all wiring in accordance with all local and national codes. Refer to Division 26, Electrical Specifications for areas requiring more stringent installation procedures.

2. Provide 120-volt branch circuits from junction boxes to DDC panels.

3. Provide 120VAC for all instruments, valves, dampers, and control devices requiring 120VAC supply. All work shall be installed in accordance with Division 26.

4. Provide 24-volt power, control and network interface wiring from network DDC controllers and panels to all application specific controllers (VAVs, TECs etc.), local display devices through end control devices, complying with requirements of Division 26.

5. Provide BAS internal logic to coordinate all necessary fire alarm system smoke shutdown for variable frequency drive and motor starters related to emergencies as well as fire alarm system duct mounted smoke detectors.

6. Provide transformers, where required, to match control voltage with actuator or sensor voltage.

G. The Division 23, Mechanical Contractor shall provide the following:

1. All openings and pressure taps for water monitoring devices, flow switches, control valves and wells furnished by the BAS Contractor.

2. Installation of all dampers and measuring devices. All control dampers shall be furnished by BAS Contractor where not specified as an integral component of a packaged unit.

3. Furnish and install all access doors.

4. Items furnished by BAS Contractor but installed by Sections of Division 23, Mechanical Contractor:

a. Flow elements directly installed in the piping or ductwork, such as airflow measuring inlet probes, magmeters, pressure switches and thermowells.

b. Automatic control valves.

c. Control dampers.

H. The Division 26, Electrical Contractor shall provide the following.

1. Wiring of power feeds through all disconnects, starters, and to electric motors.

2. Division 26 contractor to provide all line voltage 120 VAC power wiring from electrical panels to junction boxes for the purpose of powering control panels. Junction boxes to be provided by Division 26 and shall be wired in conduit from dedicated circuits. Division 26 shall provide circuit breakers at all electrical panels for use by the BAS contractor.

3. Motor starters and motor feeder

I. The Division 28, Fire Alarm System Contractor shall provide the following.

1. Wiring of power feeds through all smoke detectors.

2. Smoke detectors shall be furnished by Division 28 and installed by Division 23.

3. All necessary monitored relays and outputs to BAS for the purposes of alarming and smoke control functions and pressurization as required by BAS and described herein and on contract drawings.

1.8 REFERENCE STANDARDS

A. All work shall conform to the following Codes and Standards, where applicable:

1. National Fire Protection Association (NFPA) Standards, as specified.
2. National Electrical Code (NEC) and applicable local Electrical Code.
3. Underwriters' Laboratories (UL) listing and labels, as specified.
4. Factory Mutual (FM).
5. American National Standards Institute (ANSI).
6. National Electric Manufacturers' Association (NEMA).
7. American Society of Mechanical Engineers (ASME).
8. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
9. Air Movement and Control Association (AMCA).
10. Institute of Electrical and Electronic Engineers (IEEE).
11. American Standard Code for Information Interchange (ASCII).
12. Manufacturer's Standardization Society of the Valve and Fitting Industry (MSS).
13. Electronics Industries Association (EIA).
14. Occupational Safety and Health Administration (OSHA).
15. American Society for Testing and Materials (ASTM).
16. NFPA 92A and 92B
17. NFPA 101, 2002

1.9 ACTION SUBMITTALS

A. Submissions Requirements:

1. Clearly identify each submittal requirement indicated and in which submission the information will be provided.

2. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

3. The following table defines the required submittals and hierarchy for time of submission:

Action Submittals		
Submittal #	**Submittal Name**	**Pre-requisite for Review**
1	Submittal Schedule	None
2	Qualification Data	None
3	Specification Compliance Submittal	1
4	Product Data for DDC system	3
5	Individual sensor/device product data	3
6	BTL listing submittal	3
7	Software submittal	3
8	Valve, Damper, and Actuator Delegated Design	3
9	Shop Drawings	3
10	Interface Control Documents	4
11	System Description	4,5 and 10
12	Sample Package (graphics and visible sensors)	4 and 9
13	Closeout Submittal Package	10, 11, and 12

B. Specification Compliance:

1. As part of the submittal package, the contractor shall include a complete copy of specifications, with confirmation of conformance to each specification section. In the case of non-conformance, the contractor shall specifically highlight the specification section of non-conformance.

C. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.

2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

3. Product description with complete technical data, performance curves, and product specification sheets.

4. Documentation on submitted products that have been tested and listed by the BTL or a letter from manufacturer's indicating the anticipated date by which testing is expected to be complete. If for any reason, BTL testing and listing has not been completed, a written commitment shall be provided to upgrade installed controls to a version that meets BTL testing and listing requirements should deficiencies be found during BTL testing.

5. Installation, operation and maintenance instructions including factors effecting performance.
6. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
    a. Servers.
    b. Gateways.
    c. Routers.
    d. Protocol analyzers.
    e. DDC controllers.
    f. Enclosures.
    g. Electrical power devices.
    h. UPS units.
    i. Accessories.
    j. Instruments.
    k. Control dampers and actuators.
    l. Control valves and actuators.
7. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
8. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

D. Software Submittal:

1. As part of the submittal package, the contractor shall include a complete copy of specifications, with confirmation of conformance to all specifications. In the case of non-conformance, the contractor shall specifically highlight the specification section of non-conformance.
2. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
3. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
4. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
5. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
6. Listing and description of each engineering equation used with reference source.
7. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
8. Description of operator interface to alphanumeric and graphic programming.
9. Description of each network communication protocol.

10. Description of system database, including all data included in database, database capacity and limitations to expand database.
11. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
12. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

E. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.
2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.

F. For DDC system products and installation indicated as being delegated.

1. Schedule and design calculations for control valves, and actuators.
    a. Flow at Project design and minimum flow conditions.
    b. Pressure-differential drop across valve at Project design flow condition.
    c. Valve authority at design conditions.
    d. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
    e. Design and minimum control valve coefficient with corresponding valve position.
    f. Maximum close-off pressure.
    g. Leakage flow at maximum system pressure differential.
    h. Torque required at worst case condition for sizing actuator.
    i. Actuator selection indicating torque provided.
    j. Actuator signal to control damper (on, close or modulate).
    k. Actuator position on loss of power.
    l. Actuator position on loss of control signal.
2. Schedule and design calculations for control dampers, and actuators.
    a. Flow at Project design and minimum flow conditions.
    b. Pressure-differential drop across damper at Project design flow condition.
    c. Maximum close-off pressure.
    d. Leakage flow at maximum system pressure differential.
    e. Torque required at worst case condition for sizing actuator.
    f. Actuator selection indicating torque provided.
    g. Actuator signal to control damper (on, close or modulate).

h. Actuator position on loss of power.

i. Actuator position on loss of control signal.

G. Shop Drawings:

1. General Requirements:

a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.

b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.

c. Prepare Drawings using computer software, and provide digital copies to owner.

d. Scanned drawings are not acceptable.

2. Include plans, elevations, sections, and mounting details where applicable.

3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

4. Detail means of vibration isolation and show attachments to rotating equipment.

5. Plan Drawings indicating the following:

a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.

b. Room names and numbers with coordinated placement to avoid interference with control products indicated.

c. Each desktop operator workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.

d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.

e. Network communication cable and raceway routing.

f. Information, drawn to scale.

g. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.

6. Schematic drawings for each controlled system indicating the following:

a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.

b. I/O listed in table format showing point name, type of device, manufacturer, model number, point address, and cross-reference to product data sheet number.

c. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.

d. Unique identification of each I/O that shall be consistently used between different drawings showing same point.

e. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.

f. A contractors written sequence of operation for all systems, with specific IO reference by name and number.

7. Control panel drawings indicating the following:

a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.

b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.

c. Unique drawing for each panel.

8. DDC system network riser diagram indicating the following:

a. Each device connected to network with unique identification for each.

b. Interconnection of each different network in DDC system.

c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or fiber-optic cable type. Indicate raceway type and size for each.

d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

9. DDC system electrical power riser diagram indicating the following:

a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.

b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.

c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.

d. Power wiring type and size, raceway type, and size for each.

10. Monitoring and control signal diagrams indicating the following:

a. Pneumatic main air and control signal tubing to pneumatic damper and valve actuators, pilot-positioners if applicable, and associated transducers.

11. Color graphics indicating the following:

a. Itemized list of color graphic displays to be provided.

b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.

c. Intended operator access between related hierarchical display screens.

H. Interface Control Documents (ICD's):

1. For each subsystem being integrated into the BAS system (lighting controls, chillers, etc.) the contractor shall submit a complete interface control document, coordinated with the approved 3rd party submittals, detailing at a minimum:
    a. Communication type
    b. Connection point
    c. All input and output capability between the two systems
    d. Connection coordination with 3rd party
    e. Graphical interface capability

I. System Description:
1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:
    a. Loss of power.
    b. Loss of network communication signal.
    c. Loss of controller signals to inputs and outpoints.
    d. Operator workstation failure.
    e. Server failure.
    f. Gateway failure.
    g. Network failure
    h. Controller failure.
    i. Instrument failure.
    j. Control damper and valve actuator failure.
4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

J. Samples:
1. For each of the following exposed product, installed in finished space for approval of selection of aesthetic characteristics:
    a. All proposed space temperature, humidity, CO2, pressure, and occupancy sensors for review and written approval by owner's representative.
    b. Provide sample of label to be provided for each control device with setting or adjustable range of control for written approval by Owner's Representative.

c. Provide sample(s) of proposed graphic for review and written approval by Owner's Representatives. Graphic samples must be included as part of the original shop drawing submittal package for owner and engineer to review.

1.10 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. Systems Provider Qualification Data:

a. Resume of project manager assigned to Project.

b. Resumes of application engineering staff assigned to Project.

c. Resumes of installation and programming technicians assigned to Project.

d. Resumes of service technicians assigned to Project.

e. Description of past project DDC system, noting similarities to Project scope and complexity indicated.

f. Owner contact information for past project including name, phone number, and e-mail address.

g. Contractor contact information for past project including name, phone number, and e-mail address.

1.11 CLOSEOUT SUBMITTALS

A. Factory Testing Results

1. Submit for approval test reports from the factory program testing procedures.

B. Final Graphic Submittal

1. Submit for approval final graphic samples of all system types (AHU's,VAV's, energy management, integrated systems, etc.).

C. Sensor Calibration Report

1. Submit for approval, a detailed report of the sensor calibration process. The report shall consist of both testing procedures and testing results. Any sensor that has been factory calibrated shall have the factory calibration report included in the calibration submittal.

D. DDC System I/O Checkout Report

1. Submit for approval, a detailed report highlighting the process and results as described in section, "DDC SYSTEM I/O CHECKOUT PROCEDURES".

E. As-built documentation

1. Submit for approval, as-built versions of shop drawings and product data in electronic PDF format. The as-built drawings, drawings, sequences, and products shall accurately reflect every change made to the system operation since approval of the shop drawings.

F. System readiness confirmation

1. Submit for approval written confirmation of system readiness for testing as defined in section “Final Review”.

G. Validation test report

1. Submit for approval all procedures and results as described in section “DDC System Validation Tests”.

H. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:

a. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.

b. As-built versions of submittal Product Data.

c. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.

d. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.

e. A complete alarm list, with criticality levels, and distribution assignment.

f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

g. Engineering, installation, and maintenance manuals that explain how to:

1) Design and install new points, panels, and other hardware.

2) Perform preventive maintenance and calibration.

3) Debug hardware problems.

4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.

i. Submission of actual programming language used for each system type.

j. Backup copy of graphic files, programs, and database on electronic media such as DVDs.

k. List of recommended spare parts with part numbers and suppliers.

l. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

m. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.

n. Licenses, guarantees, and warranty documents.

o. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

p. Owner training materials.

1.12 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of 10 years within time of bid.
3. Manufacturer must have a minimum of 3 different vendors, with technical staff, spare parts inventory, and all necessary test and diagnostic equipment for a period of not less than 10 years, that can service the software and hardware of the system within 100 miles of the project site:
4. DDC systems and products that have been successfully tested and in use on at least five past projects.
5. Having complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.
6. Comply with ASHRAE 135 for DDC system components.
7. Having full-time in-house employees for the following:
   a. Product research and development.
   b. Product and application engineering.
   c. Product manufacturing, testing and quality control.
   d. Technical support for DDC system installation training, commissioning and troubleshooting of installations.
   e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. In-place facility located within 100 miles of Project, with technical staff, spare parts inventory, and all necessary test and diagnostic equipment for a period of not less than 10 years.
3. Demonstrated past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
4. Provide service and support availability 24 hours per day, 7 days per week and shall be able to respond to service calls within a 24 hour period or less.
5. Demonstrated past experience on five projects of similar complexity, scope and value.
6. Each person assigned to Project shall have demonstrated past experience.

7. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
8. Service and maintenance staff assigned to support Project during warranty period.
9. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
10. DDC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

1.13 PRE-INSTALLATION CONFERENCE

A. Convene a conference one week prior to commencing work of this Section, under provisions of General Conditions and Division 1 and Section 230500 as applicable. Convene a conference one week prior to commencing work of this Section, under provisions of General Conditions and Division 1 and Section 230500 as applicable. The owner or his designated representative shall be present at this meeting. The installer will review hardware and software requirements for the interface points, network identifiers, wiring requirements, communication speeds, and required network accessories. The purpose of this meeting shall be to insure there are no unresolved issues regarding the installation of the system or the sequence of operations. Submittals for these products shall not be approved prior to the completion of this meeting.

B. Require attendance of parties directly affecting the work of this Section.

1.14 FACTORY PROGRAM WITNESS TESTING

A. The contractor shall facilitate factory testing of programming in advance of shipment of any of the controllers to site. The factory shall have the ability to fully simulate and modify all inputs (both digital and analog) to simulate real installed conditions. Testing procedures for the factory programming shall be developed by the commissioning authority and shall reflect the procedures used during final functional performance testing. The following samples are required to be factory tested for proper programming:

1. VAV w/reheat and FTR
2. 4-pipe fan coil unit
3. Typical AHU
4. Chilled Water System
5. Hot Water System

B. Required attendance shall include at a minimum an Owner’s representative, EOR representative, and the CxA.

1.15 EXTRA MATERIALS

A. Submit maintenance materials under provisions of General Conditions and Division 1 as applicable.

B. Provide spare parts list.

1.16 PROTECTION OF SOFTWARE RIGHTS

A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:

1. Limiting use of software to equipment provided under these specifications.

2. Limiting copying.

3. Preserving confidentiality.

4. Prohibiting transfer to a third party.

1.17 CODES AND APPROVALS

A. All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local and state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications. As a minimum, the installation shall comply with current editions in effect 90 days prior to receipt of bids of the following codes. All products of the DDC system shall be provided with the following agency approvals. With the submittal documents, verification that the approvals exist for all submitted products shall be provided. Systems or products not currently offering the following approvals are not acceptable.

1. NEMA standards pertaining to components and devices for DDC control systems.

2. NEMA EMC1 - Energy Management Systems Definitions.

3. Requirements of NEC pertaining to installation of DDC control systems, including, but not limited to, remote-control, signaling and power-limited circuits.

4. Provide DDC control system components and ancillary equipment which are UL-listed and labeled.

5. The BAS system shall be UL916PAZX listed.

6. Federal Communications Commission (FCC) Rules, pertaining to components and devices for DDC control systems and Section 15 governing radio frequency electromagnetic interference and be so labeled

7. Electronic Industries Association (EIA) Std RS-232 pertaining to interfacing requirements for connecting data terminals and communication equipment.

8. IEEE Std 488, "Standard Digital Interface for Programmable Instrumentation", for interfacing instrumentation into system.

9. ANSI X3.4, "Code for Information Interchange", requirements for interfacing computer data processing with communication terminal equipment.

10. ASME MC85.1 - Terminology for Automatic Control

B. The following current NFPA and ASHRAE Standards and Guides are applicable.

1. NFPA 90A “Standard for the Installation of Air Conditioning and Ventilating Systems” where applicable to controls and control sequences

2. NFPA 90B Warm Air Heating, Air Conditioning

3. NFPA 92A, Recommended Practice for Smoke-Control Systems

4. NFPA 92B, Guide for Smoke Management Systems in Malls, Atria, and Large Areas

5. ASHRAE 85 - Automatic Control Terminology for Heating, Ventilating, Air Conditioning

6. ASHRAE 135 - Building Automation and Control Networks (BACnet)

C. All system components are to be designed and built to be fault tolerant.

1. Provide satisfactory operation without damage at 110% above and 85% below rated voltage and at +3 hertz variation in line frequency.

2. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static transients and induced magnetic interference. Bus connected devices shall be AC. coupled, or equivalent so that any single failure will not disrupt or halt bus communication.

1.18 WARRANTY

A. Material: The control system shall be free from defects in material and material workmanship under normal use and service. If within thirty six (36) months from the date of completion any of the equipment herein described is defective in operation, workmanship, or materials, it shall be replaced, repaired, or adjusted at the option of the contractor free of charge.

B. Installation: The system, including all hardware, software and workmanship, shall be guaranteed for a period of one (1) year from the date of final acceptance. Any defects or deviations from the contract specifications shall be corrected by the contractor free of charge.

C. All applicable software, as detailed in this specification, shall be updated by the BAS contractor free of charge during the warranty period to insure that the system software is

the most up-to-date software available, for the system hardware installed, at the end of the warranty.

D. The system shall be free from defects in installation workmanship for a period of one year from acceptance. The BAS Contractor shall, free of charge, correct any defects in workmanship within one week of notification in writing by the Owner.

E. All corrective software modifications made during the warranty service period shall be updated on all user documentation and on user and manufacturer archived software disks.

PART 2 - PRODUCTS

2.1 ACCEPTABLE BAS PLATFORMS

A. Manufacturer: Company shall be one of the following Platforms. The platform must have a minimum of 3 different vendors that can service the software and hardware of the system within 100 miles of the project site:

1. Automated Logic Corporation

2. Alerton Controls

B. Installers/Integrators: Company specializing in applying the work of this section with minimum 10 years documented experience approved by the manufacturer and determined acceptable following a review of pre bid qualification package.

2.2 Environment

A. All equipment detailed in this specification or other equipment associated with the BAS shall be capable of operation in the environmental conditions where equipment is located.

1. If product alone cannot properly operate in the final installed location, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

B. Equipment shall be able to operate at a minimum between the following conditions:

1. 0-45°C (32°F – 113°F)

2. 0-95% RH

2.3 DDC SYSTEM DESCRIPTION:

A. The building management system provided and installed shall be a distributed logic control system complete with all software and hardware functions. The system shall be based on ANSI/ASHRAE Standard 135, BACnet controlling all mechanical equipment

using BTL (BACNET Testing Labs) Certified native BACnet-compliant components. The system must use BACnet as the native communication protocol between workstations/servers and the network.

B. The building management system shall consist of the following:

1. Stand-alone Network Controllers for all main equipment (AHU's, chilled water systems, hot water systems, etc.). The intent of this specification is that the loss of any one controller shall not affect the operation of other HVAC systems. It shall only affect the points connected to the failed DDC controller. It is not acceptable that any control loops are split across two or more DDC control panels.

2. Stand-alone Programmable Application Controllers (PACs) shall only be used for terminal equipment (VAV's, FCU's, chilled beams, unit heaters, etc.).

3. Application Specific Controllers which are designed for a specific piece of equipment, that are configurable and customizable.

C. The system shall be modular in nature and permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.

D. Controllers shall assign password access and control priorities to either fully assignable point groups or each point individually. The logon password (at PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and/or control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (E.g. all base points shall be accessible to any base building operators, but only electrical points shall be accessible to house electricians). Passwords and priority levels for every point shall be fully programmable and adjustable.

E. The BAS system shall operate with an input voltage rated at 120 Volts, 1 phase, 60 Hertz. All units shall be grounded in accordance with the local Electrical Code and the NEC. All units shall be supplied with filtered power, if required, to preclude noise generation. Signal range shall be 4-20 mA or 0-10 VDC or 2-12 VDC.

F. The BAS shall be programmed to automatically detect critical alarms that require notification, create an action statement for each alarm, and select the person to receive the notification via e-mail, pager, and cell phone. Software shall operate with any numeric or alphanumeric paging system. Paging database shall be password protected. When a critical alarm occurs, a paging box is automatically displayed indicating which report is being sent to which pager and the progress of the page. For alphanumeric systems, page shall indicate exactly where and what alarm has occurred so that an operator can go directly to the problem without need of an operator terminal to diagnose the problem.

G. The control system shall be a high speed, peer to peer BACnet network of DDC controllers and a web based operator interface. All schedules, setpoints, trends, and alarms shall be BACnet objects.

H. Workstation information access shall be BACnet protocol. Communications shall use ISO 8802-3 (Ethernet) Data Link/ Physical layer protocol.

I. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 WEB ACCESS

A. DDC system shall be Web compatible.

1. Web-Compatible Access to DDC System:

a. Operator workstation and server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.

b. DDC system shall support Web browser access to building data. Operator using a standard Web browser shall be able to access control graphics and change adjustable set points. The web server shall be configured in such a way that there is not software imposed limit to the number of simultaneous users. The web interface shall include at a minimum:

1) Data Sharing: Presentation of data (user definable reports and graphics, ability to monitor and display the values of all BACnet object types, including all required and optional properties, ability to modify setpoints and parameters.

2) Alarm and Event Management: Operator notification and presentation of event notification, Alarm acknowledgement by operators, alarm summarization, adjustment of alarm limits, adjustment of alarm routing.

3) Scheduling: modification of schedules, display of the start-stop times (schedule) of scheduled devices.

4) Trending: Modification of the parameters of a trend log, display and archive of trend log.

5) Device and Network Management: display of information about the status of any device on the BACnet internet work. Ability to silence a device on the network that is transmitting erroneous data, ability to cause a remote device to reinitialize itself, ability to backup and restore the configuration of devices on the local BACnet network and the ability to query and change the configuration of local BACnet routers.

c. Web access shall be password protected.

2.5 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:

a. DDC system shall manage HVAC systems.

b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.

c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.

d. DDC system shall operate while unattended by an operator and through operator interaction.

e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.

2. Smoke-Developed Index: 50 or less.

C. DDC System Speed:

1. Response Time of Connected I/O:

a. AI point values connected to DDC system shall be updated at least every two seconds for use by DDC controllers. Points used globally shall also comply with this requirement.

b. BI point values connected to DDC system shall be updated at least every two seconds for use by DDC controllers. Points used globally shall also comply with this requirement.

c. AO points connected to DDC system shall begin to respond to controller output commands within one second(s). Global commands shall also comply with this requirement.

d. BO point values connected to DDC system shall respond to controller output commands within one second(s). Global commands shall also comply with this requirement.

2. Display of Connected I/O:

a. Analog point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.

b. Binary point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.

c. Alarms of analog and digital points connected to DDC system shall be displayed within 15 seconds of activation or change of state.

d. Graphic display refresh shall update within four seconds.

e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

D. Network Bandwidth: Design each network of DDC system to include at least 50 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

E. DDC System Data Storage:

1. Include server(s) with disk drive data storage to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated. The server shall be initially setup to trend all analog inputs and outputs on 15 minute intervals and all binary inputs and outputs on a COV basis. The Server shall also be set up to trend all space setpoints on a COV basis, and operating setpoints (static pressure/differential pressure etc.) on a 15 minute basis.
2. When logged onto a server, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
3. Server(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
4. Server(s) shall use IT industry-standard database platforms such as Microsoft SQL Server and Microsoft Data Engine (MSDE).

F. Future Expandability:

1. DDC system size shall be expandable to an ultimate capacity of at least four times total I/O points indicated.
2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

G. Environmental Conditions for Controllers, Gateways, Routers, instruments, sensors, and actuators:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
    a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.
2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

a. Outdoors, Protected: Type 12.

b. Outdoors, Unprotected: Type 4X.

c. Indoors, Heated with Filtered Ventilation: Type 1.

d. Indoors, Heated with Non-Filtered Ventilation: Type 12.

e. Indoors, Heated and Air Conditioned: Type 1.

f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: Type 4X.

2) Air-Moving Equipment Rooms: Type 2.

g. Localized Areas Exposed to Washdown: Type 4X.

h. Hazardous Locations: Explosion-proof rating for condition.

H. Electric Power Quality:

1. Power-Line Surges:

a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.

b. Do not use fuses for surge protection.

I. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

J. UPS:

1. DDC system products powered by UPS units shall include the following:

a. Servers.

b. Gateways.

c. DDC controllers, except application-specific controllers.

K. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.6 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than two levels of LANs.

B. DDC system shall consist of dedicated and separated LANs that are not shared with other building systems and tenant data and communication networks.

C. The control network shall be provided with a 10/100bT IP based backbone to interconnect all network controllers, programmable application controllers, application specific controllers, and servers.

D. Minimum Data Transfer and Communication Speed:

1. LAN Connecting Servers and Network Controllers: 100 Mbps.
2. LAN Connecting Programmable Application Controllers: 1000 kbps.
3. LAN Connecting Application-Specific Controllers: 1000 kbps.

E. System architecture shall be modular and have inherent ability to expand to not less than three times system size indicated with no impact to performance indicated.

F. System architecture shall perform modifications without having to remove and replace existing network equipment.

G. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

H. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

2.7 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable operator workstation with hardwired connection through LAN port.
2. Portable operator terminal with hardwired connection through LAN port.
3. Remote connection using outside of system personal computer or PDA through Web access.

B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable operator workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Each mechanical equipment room.
2. Each boiler room.
3. Each chiller room or outdoor chiller yard.
4. Each cooling tower location.
5. Each different roof level with roof-mounted air-handling units or rooftop units.

6. Security system command center.
7. Fire-alarm system command center.

D. Desktop Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.

E. Portable Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
3. Have dynamic graphic displays that are identical to desktop workstations.

F. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.
4. All alarm notification assignment shall be completed as part of the scope of the project. The controls contractor shall coordinate and work with the owner's facilities department to select alarm points, high and low limits, and the assignment of criticality, as well as the descriptor to each alarm. A complete alarm list and criticality level shall be submitted in as-built documentation.

G. Simultaneous Operator Use: Capable of accommodating up to 10 simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.8 NETWORKS

A. Acceptable networks for connecting operator workstations and network controllers include the following:

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. IP.
4. IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. IP.
4. IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:

1. ATA 878.1, ARCNET.
2. EIA-485A.
3. IP.
4. IEEE 8802-3, Ethernet.

2.9 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to public and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

C. CEA-709.1-C Protocol:

1. DDC system shall be an open implementation of LonWorks technology using CEA 709.1-C communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for communication throughout DDC system.
2. LNS shall be used for all network management including addressing and binding of network variables.
    a. Final LNS database shall be submitted with Project closeout submittals.
    b. All devices shall be online and commissioned into LNS database.
3. All devices connected to DDC system network(s) shall use CEA-709.1-C protocol and be installed so SCPT output from any node on network can be bound to any other node in the domain.

D. Industry Standard Protocols:

1. DDC system shall use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:
   a. ASHRAE 135.
   b. Modbus Application Protocol Specification V1.1b.
2. Operator workstations and network controllers shall communicate through ASHRAE 135 protocol.
3. Portions of DDC system networks using ASHRAE 135 communication protocol shall be an open implementation of network devices complying with ASHRAE 135. Network devices shall be tested and listed by BACnet Testing Laboratories.
4. Portions of DDC system networks using Modbus Application Protocol Specification V1.1b communication protocol shall be an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b.
5. Gateways shall be used to connect networks and network devices using different protocols.

2.10 SYSTEM SOFTWARE

A. System Software Minimum Requirements:
   1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
   2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
   3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
   4. Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.
   5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
   6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:
   1. Minimize operator training through use of English language prorating and English language point identification.
   2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.

3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:
    a. Operator access to DDC system shall be under password control.
    b. An alphanumeric password shall be field assignable to each operator.
    c. Operators shall be able to access DDC system by entry of proper password.
    d. Operator password shall be same regardless of which computer or other interface means is used.
    e. Additions or changes made to passwords shall be updated automatically.
    f. Each operator shall be assigned an access level to restrict access to data and functions the operator is cable of performing.
    g. Software shall have at least five access levels.
    h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
    i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.
7. Data Segregation:
    a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
    b. Include at least 32 segregation groups.
    c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
    d. Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.
    e. Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
    f. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.
8. Operators shall be able to perform commands including, but not limited to, the following:
    a. Start or stop selected equipment.
    b. Adjust set points.

c. Add, modify, and delete time programming.

d. Enable and disable process execution.

e. Lock and unlock alarm reporting for each point.

f. Enable and disable totalization for each point.

g. Enable and disable trending for each point.

h. Override control loop set points.

i. Override both input and output values.

j. Enter temporary override schedules.

k. Define holiday schedules.

l. Change time and date.

m. Enter and modify analog alarm limits.

n. Enter and modify analog warning limits.

o. View limits.

p. Enable and disable demand limiting.

q. Enable and disable duty cycle.

r. Display logic programming for each control sequence.

9. Reporting:

a. Generated automatically and manually.

b. Sent to displays, printers and disk files.

c. Types of Reporting:

1) General listing of points.

2) List points currently in alarm.

3) List of off-line points.

4) List points currently in override status.

5) List of disabled points.

6) List points currently locked out.

7) List of items defined in a "Follow-Up" file.

8) List weekly schedules.

9) List holiday programming.

10) List of limits and deadbands.

10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path

operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.

2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.
5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
7. Graphics are to be online programmable and under password control.
8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics shall also contain software points.
10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
11. Display operator accessed data on the monitor.
12. Include operator with means to directly access graphics without going through penetration path.
13. Provide an automatically updated, dynamic display of the site specific BAS architecture indicating the status of all controllers, PC workstations and networks.
14. Dynamic data shall be assignable to graphics.
15. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
16. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.
    a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
    b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
    c. Keyboard equivalent shall be available for those operators with that preference.
    d. At a minimum, the following operator command shall be available through the head end:
        1) Auto (normal programmed state)

2) Time based override

3) Set (indefinite override)

17. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.

    a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols similar to those indicated.

    b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:

        1) Define background screens.

        2) Define connecting lines and curves.

        3) Locate, orient and size descriptive text.

        4) Define and display colors for all elements.

        5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.

2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

    a. Room layouts with room identification and name.

    b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.

    c. Location and identification of each hardware point being controlled or monitored by DDC system.

3. Control schematic, including a graphic system schematic representation, for each piece of equipment indicated on Drawings, with point identification, set point values and dynamic value indication.

4. The related sequence of operation and control logic diagram shall be linked to the control schematic graphic. The sequence of operations shall be in an editable text file format.

5. All controls system as-builts for the associated equipment shall be provided as on page links.

6. All related testing and balancing reports shall be provided as on page links with associated equipment.

7. All related approved equipment cut-sheets shall be provided as on page links with associated equipment.

8. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all available points associated with equipment.
9. For each graphical interface page, the current weather conditions, time, and date shall be displayed.
10. For each equipment graphic, all current active setpoints and operating mode shall be displayed on the interface.
11. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways operator workstations and other network devices.
12. For each air handling unit provide a tabular graphic summary of that unit and its associated air distribution system. Graphics shall contain, at a minimum, the following information:
    a. All points shown on the associated controls drawings.
    b. Summary of associated terminal unit damper positions(average, min, max, percentage below 90% open).
    c. Current calculated differential pressure setpoints and hydronic temperature setpoints.
    d. A link to energy trending page with graphical representation of all system energy usage.
    e. Commissioning override to force all terminal units to maximum cooling setpoint, minimum cooling setpoint, or a percentage in-between.
13. For each central heating or cooling plant provide a tabular graphic summary of that unit and its associated air distribution system. Graphics shall contain, at a minimum, the following information:
    a. All points shown on the associated controls drawings.
    b. Summary of associated valve positions (average, min, max, percentage below 90% open).
    c. Current calculated supply air static pressure setpoint and discharge air temperature setpoint.
    d. A link to energy trending page with graphical representation of all unit energy usage.
    e. Commissioning override to force all valves to maximum cooling/heating setpoint, fully closed, or a percentage in-between.
14. For each terminal device provide a tabular graphic summary of that unit and its associated air distribution system. Graphics shall contain, at a minimum, the following information:
    a. All points shown on the associated controls drawings.
    b. Summary of associated valve/damper positions.
    c. All calculated setpoints.

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.

3. As a minimum, include the following modification capability:
   a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
   b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
   c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.
   d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.
   e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.
   f. Point related change capability shall include the following:
      1) System and point enable and disable.
      2) Run-time enable and disable.
      3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
      4) Assignment of alarm and warning limits.
   g. Application program change capability shall include the following:
      1) Enable and disable of software programs.
      2) Programming changes.
      3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.
4. Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.
5. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.
6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:
   a. Proportional control (P).

b. Proportional plus integral (PI).

c. Proportional plus integral plus derivative (PID).

d. Adaptive and intelligent self-learning control.

1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.

2) Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.

8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.

9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.

10. Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.

2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.

3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.

4. Alarms display shall include the following:

a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."

b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."

c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."

d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.

6. Send e-mail alarm messages to designated operators.

7. Send e-mail, page, text and voice messages to designated operators for critical alarms.
8. Alarms shall be categorized and processed by class.
9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.
11. Alarms shall be categorized and processed by class.
    a. Class 1:
        1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
        2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
        3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.
    b. Class 2:
        1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
        2) Acknowledgement may be through a multiple alarm acknowledgment.
    c. Class 3:
        1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
        2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
        3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
        4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.
    d. Class 4:
        1) Routine maintenance or other types of warning alarms.
        2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.
12. The following standard alarm types shall be provided at a minimum:

a. General Mismatch - Mismatch: The alarm is associated with an output command point and an input giving status feedback of the output command. The alarm is generated when the status feedback does not correspond with the output command status for longer than a defined time delay period of 5 minutes(adj.).

b. General Analog - The alarm is associated directly with an analog input. The alarm is generated by the BAS due to a measured variable exceeding specified limits. It shall be possible to define the limits in two ways:

1) Fixed limits. The point has fixed upper and lower alarm limits. If the measured variable rises above the upper limit, or falls below the lower limit, then an alarm is generated. e.g. high alarm limit = 80°F, low alarm limit = 45°F.

2) Floating limits. The point has an associated setpoint, and an alarm is generated when the measured variable deviates either above or below the setpoint by more than a given alarm limit value. If the setpoint is changed, the alarm limits are automatically moved to suit, e.g. setpoint = 66°F, alarm limits = Setpoint ± 2°F.

c. Hand/Off/Auto (HOA) - The alarm is associated with the placement of the HOA switches in the Hand or Off position. HOA switches include but are not limited to controllers and variable frequency drives.

G. Automated Fault Detection and Diagnostic Software:

1. The system shall be provided with a dedicated graphical subsystem interface for AFDD and building performance monitoring, that graphically shows the time and duration of each fault as well as conditions and other information related to the faults.

2. The interface shall be provided with a separate security level for interface, and separate notification pathway from standard building alarms.

3. All programs shall be completely customizable and adjustable through the AFDD interface.

4. AFDD will deliver a minimum level monitoring as detailed in the sequence of operations. AFDD will also include as part of their submittal, a list of additional rules/faults for owner review. The contractor shall provide time allocation for programming/implementing an additional 15 rules beyond what is required in the sequence of operations.

a. The AFDD system shall be able to identify typical deficiencies including but not limited to :

1) AHU

a) Simulataneous heating and cooling

b) Poor scheduling

c) Poor reset strategies (temperature and static pressure)

d) System cycling

2) Heating/Cooling Plant

a) Overall system efficiency

b) Setpoint optimization

c) Pumping system efficiency

d) Equipment cycling

3) Terminal units

a) Simultaneous heating and cooling

b) Poor scheduling

c) Poor setpoint control

d) Malfunctioning airflow control

5. The AFDD system shall be provided with a set of rules for determining the stability of control devices.

6. The AFDD system shall be capable of determining sensor accuracy and errors via out-of range comparisons, and similar sensor comparisons.

7. The AFDD system shall be capable of determining malfunctioning valves and dampers.

8. The AFDD system shall be able to diagnose the reliability of flow measurement devices (both air and water).

9. The AFDD system will be deployed on all major AHU's, chillers, pumps, fans, terminal units, and metering systems.

10. The system will be capable of monitoring and storing all points from the BAS, including all meters on a minimum 15 minute intervals for 2 years.

11. The system shall be capable of automatically calculating estimated cost of malfunctions based on historical data. The estimated costs will be presented in the fault dashboard.

12. The AFDD system shall enable users to filter and prioritize on the criticality of faults, duration of fault, potential cost of faults, etc.

13. The AFDD interface shall be a cloud-based application that can be accessed by any internet connected device with a web browser.

14. The AFDD provider shall host the software and data storage with off-site servers that shall require no maintenance or management by the building personnel. The AFDD provider shall be responsible for database maintenance and upgrades and collected data integrity for a minimum of 2 years.

    a. Add-alternate: The provider shall offer monitoring service includes savings analysis, maintenance reduction analysis, recurring report delivery.

15. The AFDD system shall be capable of categorizing faults based on their building impact. Example categories include, comfort issues, equipment failure, and energy performance. The vendor shall work with the client to determine the goals and objectives of the facility and work to apply the rules that will most appropriately achieve their facilities goals.

16. Pre-installation Conference

a. Prior to commencing the installation, a meeting at the project site will be conducted to review the implementation strategy, default rules, optional rules, and general system operations with the owner. The meeting time shall be coordinated with the system owner.

17. The base AFDD system shall be in service upon 1 month after controls contractor has indicated substantial completion of the DDC system. The AFDD system shall be made available to the CxA to facilitate the acceptance testing of the building.

18. The system shall allow unlimited number of users without additional cost that can access the system simultaneously.

19. Post installation demonstration and training:

    a. Upon successful deployment, the vendor shall provide a full day, recorded training, to the owner on the operating procedures for the AFDD system.

H. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.

2. Each report shall be definable as to data content, format, interval and date.

3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server for historical reporting.

4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.

5. Reports and logs shall be stored on server hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.

6. Reports and logs shall be able to be displayed in standard graphical chart formats, e.g. standard trend format, 2D bar chart, 3D bar chart, pie chart, X/Y scatter chart, etc.

7. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

I. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.

1. All I/O: With current status and values.

2. Alarm: All current alarms, except those in alarm lockout.

3. Disabled I/O: All I/O points that are disabled.

4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.

5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.

6. Logs:

    a. Alarm history.

    b. System messages.

    c. System events.

d. Trends.

J. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

K. Tenant Override Reports: Prepare Project-specific reports.

1. Weekly report showing daily total time in hours that each tenant has requested after-hours HVAC.
2. Monthly report showing daily total time in hours that each tenant has requested after-hours HVAC.
3. Annual summary report that shows after-hours HVAC usage on a monthly basis.

L. HVAC Equipment Reports: Prepare Project-specific reports.

M. Utility Reports: Prepare Project-specific reports.

1. Electric Report:
2. Natural Gas Report:
3. Service Water Report:

N. Energy Reports: Prepare Project-specific daily, weekly, monthly, annual, and since-installed energy reports.

1. Prepare purchased energy utility report for each submetered area that indicates the following:
   a. Time period being reported with beginning and end date, and time indicated.
   b. Gross area served.
   c. Energy consumption by energy utility type.
   d. Energy consumption per unit area by energy utility type.
   e. Total energy consumption of all utilities in common units of measure.
   f. Total energy consumption of all utilities in common units of measure per unit area.
   g. Unit energy cost by energy utility type.
   h. Energy cost by energy utility type.
   i. Energy cost per unit area by energy utility type.
   j. Total cost of all energy utilities.
   k. Total cost of all energy utilities per unit area.

O. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Trends shall be associated into groups, and a trend report shall be set up for each group.

3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

P. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

1. Each trend shall include interval, start time, and stop time.
2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server hard drives.
3. Data shall be retrievable for use in spreadsheets and standard database programs.

Q. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Programming software shall be one of the following:
   a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.
      1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
      2) Programming tools shall be viewable in real time to show present values and logical results of each function block.
   b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.
   c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.
3. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

2.11 OFFICE APPLICATION SOFTWARE

A. Products: Subject to compliance with requirements, provide the following:

1. Microsoft Corporation; Office Professional.

B. Include current version of office application software at time of Substantial Completion.

C. Office application software package shall include multiple separate applications and use a common platform for all applications, similar to Microsoft's "Office Professional."

1. Database.
2. E-mail.
3. Presentation.
4. Publisher.
5. Spreadsheet.
6. Word processing.

2.12 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.13 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. The controllers shall be provided with their own internal battery backup power supply, capable of maintaining all memory including the real time clock for not less than 72 hours. The battery shall be easily replaceable i.e. not soldered to the printed circuit board (PCB).

F. Power and Noise Immunity:

1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.

2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.

2. Means to quickly and easily disconnect controller from network.

3. Means to quickly and easily access connect to field test equipment.

4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

H. Input and Output Point Interface:

1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.

2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.

3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.

4. AIs:

a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.

b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.

c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.

d. Signal conditioning including transient rejection shall be provided for each AI.

e. Capable of being individually calibrated for zero and span.

f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.

5. AOs:

a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.

b. Output signals shall have a range of 4 to 20 mA dc or zero- to 10-V dc as required to include proper control of output device.

c. Capable of being individually calibrated for zero and span.

d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.

6. BIs:

a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.

b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.

c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.

d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.

e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.

7. BOs:

a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.

1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.

2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.

b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.

c. BOs shall be selectable for either normally open or normally closed operation.

2.14 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.
9. The controllers shall be provided with their own internal battery backup power supply, capable of maintaining all memory including the real time clock for not less than 72 hours. The battery shall be easily replaceable i.e. not soldered to the printed circuit board (PCB).
10. The Network Controllers shall be tested and certified by BACnet Testing Laboratory.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.

2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.15 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. The PAC shall be a fully user-programmable for standalone and networked DDC control.

2. Include adequate number of controllers to achieve performance indicated.

3. Controller shall have enough memory to support its operating system, database, and programming requirements.

4. Data shall be shared between networked controllers and other network devices.

5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.

6. Controllers that perform scheduling shall have a real-time clock.

7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.

8. Controllers shall be fully programmable.

9. The controllers shall be provided with their own internal battery backup power supply, capable of maintaining all memory including the real time clock for not less than 72 hours. The battery shall be easily replaceable i.e. not soldered to the printed circuit board (PCB).

10. The PAC shall be certified by BTL as BACnet Advanced Application Controller.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.

2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.16 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation. Connection shall extend to port on space temperature sensor that is connected to controller.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.17 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. Control functions shall be executed within controllers using DDC algorithms.
3. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

   a. Include separate schedules for each day of week.

   b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.

   c. Each schedule may consist of up to 10 events.

   d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

   a. Include ability for operator to designate any day of the year as an exception schedule.

   b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

   a. Include capability for operator to define up to 99 special or holiday schedules.

   b. Schedules may be placed on scheduling calendar and will be repeated each year.

   c. Operator shall be able to define length of each holiday period.

D. Binary Alarms:

1. Each binary point shall be set to alarm based on operator-specified state.

2. Include capability to automatically and manually disable alarming.

E. Analog Alarms:

1. Each analog object shall have both high and low alarm limits.

2. Alarming shall be able to be automatically and manually disabled.

F. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.

2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.

3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

G. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

H. Control Loops:

1. Support any of the following control loops, as applicable to control required:

a. Two-position (on/off, open/close, slow/fast) control.

b. Proportional control.

c. Proportional plus integral (PI) control.

d. Proportional plus integral plus derivative (PID) control.

1) Include PID algorithms with direct or reverse action and anti-windup.

2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.

3) Controlled variable, set point, and PID gains shall be operator-selectable.

e. Adaptive (automatic tuning).

I. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

J. Anti-Short Cycling:

1. BO points shall be protected from short cycling.

2. Feature shall allow minimum on-time and off-time to be selected.

K. On and Off Control with Differential:

1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.

2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

L. Run-Time Totalization:

1. Include software to totalize run-times for all BI and BO points.

2. A high run-time alarm shall be assigned, if required, by operator.

2.18 ENCLOSURES

A. General Enclosure Requirements:

1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
2. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
3. Freestanding enclosures shall not exceed 48 inches wide and 72 inches high.
4. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
5. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door. For enclosures with windows, include pocket on bottom of enclosure.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 10 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least ¼ inchhigh lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:

1. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
2. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.

D. Wall-Mounted, NEMA 250, Type 1:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. Hoffman; a brand of Pentair Equipment Protection; Contractor Series.
2. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
3. Hinged door full size of front face of enclosure and supported using:
4. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
5. Internal panel mounting hardware, grounding hardware and sealing washers.
6. Grounding stud on enclosure body.
7. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall Mounted NEMA 250, Types 4 and 12:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. Hoffman; a brand of Pentair Equipment Protection; Concept Series.
2. Seam and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
4. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
5. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
6. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
7. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
8. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
9. Grounding stud on enclosure body.
10. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Wall-Mounted, NEMA 250, Type 4X SS:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Hoffman; a brand of Pentair Equipment Protection; Concept Type 4X.

2. Seam and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.

G. Accessories:

1. Electric Heater:

   a. Aluminum housing with brushed finish.
   b. Thermostatic control with adjustable set point from zero to 100 deg F
   c. Capacity: 100, 200, 400, and 800 W as required by application.
   d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.

2. Ventilation Fans, Filtered Intake and Exhaust Grilles:

   a. Number and size of fans, filters and grilles as required by application.
   b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
   c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
   d. Thermostatic control with adjustable set point from 32 to 140 deg F
   e. Airflow Capacity at Zero Pressure:

      1) 4-Inch Fan: 100 cfm
      2) 6-Inch Fan: 240 cfm
      3) 10-InchFan: 560 cfm

   f. Maximum operating temperature of 158 deg F.
   g. 4-inchfan thermally protected and provided with permanently lubricated ball-bearings.
   h. 6- and 10-inchfans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.
   i. Fan brackets, finger guards and mounting hardware provided with fans to complete installation.
   j. Filters for NEMA 250, Type 1 Enclosures: Washable foam or aluminum, of a size to match intake grille.

k. Filters for NEMA 250, Type 12 Enclosures: Disposable, of a size to match intake grille.

3. Bar handle with keyed cylinder lock set.

2.19 RELAYS

A. General-Purpose Relays:

1. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
3. Relays shall have LED indication and a manual reset and push-to-test button.
4. Performance:
   a. Mechanical Life: At least 10 million cycles.
   b. Electrical Life: At least 100,000 cycles at rated load.
   c. Pickup Time: 15 ms or less.
   d. Dropout Time: 10 ms or less.
   e. Pull-in Voltage: 85 percent of rated voltage.
   f. Dropout Voltage: 50 percent of nominal rated voltage.
   g. Power Consumption: 2 VA.
   h. Ambient Operating Temperatures: Minus 40 to 115 deg F

B. Current Sensing Relay:

1. Monitors ac current.
2. Independent adjustable controls for pickup and dropout current.
3. Energized when supply voltage is present and current is above pickup setting.
4. De-energizes when monitored current is below dropout current.
5. Dropout current is adjustable from 50 to 95 percent of pickup current.
6. Include a current transformer, if required for application.
7. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

C. Combination On-Off Status Sensor and On-Off Relay:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Functional Devices Inc; RIBX series.
2. Description:
   a. On-off control and status indication in a single device.
   b. LED status indication of activated relay and current trigger.

c. Closed-Open-Auto override switch located on the load side of the relay.

3. Performance:

a. Ambient Temperature: Minus 30 to 140 deg F

b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.

4. Status Indication:

a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.

b. Current Sensor Range: As required by application.

c. Current Set Point: Fixed or adjustable as required by application.

d. Current Sensor Output:

1) Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.

2) Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.

3) Analog, zero- to 5- or 10-V dc.

4) Analog, 4 to 20 mA, loop powered.

5. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.

6. Enclosure: NEMA 250, Type 1 enclosure.

2.20 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.

2. Transformer shall be at least 40 VA.

3. Transformer shall have both primary and secondary fuses.

B. Transient Voltage Suppression and High-Frequency Noise Filter Unit:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Current Technology Inc.; Load Guard Model MSU45 series.

2. The maximum continuous operating voltage shall be at least 125 percent.

3. The operating frequency range shall be 47 to 63 Hz.

4. Protection modes according to NEMA LS-1.

5. Unit shall have LED status indicator that extinguishes to indicate a failure.

6. Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449, and as an electromagnetic interference filter per UL 1283.

C. DC Power Supply:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Acopian Technical Company; 25J series.
2. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
3. Performance:
   a. Output voltage nominally 25-V dc within 5 percent.
   b. Output current up to 100 mA.
   c. Input voltage nominally 120-V ac, 60 Hz.
   d. Load regulation within 0.5 percent from zero- to 100-mA load.
   e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
   f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.21 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

A. 250 through 1000 VA:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. APC.
2. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
3. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.
   a. Larger-capacity units shall be provided for systems with larger connected loads.
   b. UPS shall provide five minutes of battery power.
4. Performance:
   a. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.
   b. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
   c. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.
   d. On Battery Output Voltage: Sine wave.
   e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.

f. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.

g. Transfer Time: 6 ms.

h. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.

5. UPS shall be automatic during fault or overload conditions.

6. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.

7. Include front panel with power switch and visual indication of power, battery, fault and temperature.

8. Unit shall include an audible alarm of faults and front panel silence feature.

9. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.

10. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect the points to the DDC system.

11. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.

2.22 PIPING AND TUBING

A. Pneumatic, and Pressure Instrument Signal Air, Tubing and Piping:

1. Products in this paragraph are intended for use with the following:

a. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers and accessories.

2. Copper Tubing:

a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties according to ASTM B 75.

b. Performance, dimensions, weight and tolerance according to ASTM B 280.

c. Diameter, as required by application, not less than nominal 0.25 inch.

d. Wall thickness, as required by the application, but not less than 0.030 inch

3. Copper Tubing Connectors and Fittings:

a. Brass, compression type.

1) Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a) Parker Hannifin Corporation; CPI.

4. Polyethylene Tubing:

a. Fire-resistant black virgin polyethylene according to ASTM D 1248, Type 1, Class C and Grade 5.

b. Tubing shall comply with stress crack test according to ASTM D 1693.

c. Diameter, as required by application, of not less than nominal 0.25 inch.

5. Polyethylene Tubing Connectors and Fittings:

a. Brass, barbered fittings.

1) Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a) Parker Hannifin Corporation; Poly-Tite.

B. Process Tubing:

1. Products in this paragraph are intended for signals to instruments connected to liquid and steam systems.

2. Copper Tubing:

a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered with chemical and physical properties according to ASTM B 75.

b. Performance, dimensions, weight and tolerance according to ASTM B 280.

c. Diameter, as required by application, of not less than nominal 0.25 inch.

d. Wall thickness, as required by application, but not less than 0.030 inch.

3. Copper Tubing Connectors and Fittings:

a. Brass, compression type.

b. Brass, solder-joint type.

2.23 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire size shall be at least 14 AWG and meet all electrical local code requirements and in accordance with Div 26 requirements. AWG.

2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.

3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.

4. Conductor colors shall be black (hot), white (neutral), and green (ground).

5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size shall be a minimum No. 18 AWG.

2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inchlay.

3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.

4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be plenum rated.
2. Cable shall comply with NFPA 70.
3. Cable shall have a unique color that is different from other cables used on Project.
4. Copper Cable for Ethernet Network:
   a. 100BASE-TX.
   b. TIA/EIA 586, Category 5e or Category 6.
   c. Minimum No. 22 AWG solid.
   d. Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP).
   e. Thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, Class CMP as plenum rated.

2.24 RACEWAYS FOR CONTROL WIRING, CABLING, AND TUBING

A. Metal Conduits, Tubing, and Fittings:

1. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. GRC: Comply with NEMA ANSI C80.1 and UL 6.
3. IMC: Comply with NEMA ANSI C80.6 and UL 1242.
4. PVC-Coated Steel Conduit: PVC-coated IMC.
   a. Comply with NEMA RN 1.
   b. Coating Thickness: 0.040 inch , minimum.
5. EMT: Comply with NEMA ANSI C80.3 and UL 797.
6. FMC: Comply with UL 1; zinc-coated steel.
7. Fittings for Metal Conduit: Comply with NEMA ANSI FB 1 and UL 514B.
   a. Fittings for EMT:
      1) Material: Steel or die cast.
      2) Type: Setscrew or compression.

b. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

2.25 CONTROL POWER WIRING AND RACEWAYS

A. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" electrical power conductors and cables.

B. Comply with requirements in Section 26 0533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

2.26 FIBER-OPTIC CABLE, CONNECTORS, AND RACEWAY

A. Cables:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
    a. AMP NETCONNECT; a Tyco Electronics brand; a TE Connectivity Ltd. company.
    b. AT&T.
    c. Belden Inc.
    d. Berk-Tek.
    e. Communications Specialties, Inc.
    f. Corning Cable Systems.
    g. Optical Cable Corporation.
    h. Times Fiber Communications, Inc.
3. Cable Structure:
    a. Number of Fibers: Supply the required number of fibers in each cable for DDC system indicated, plus not less than 50 percent spare. Cable structure shall have fibers grouped for easy handling.
    b. Cable Jacket: Protect cable by an extruded-polyethylene jacket.

B. Cable Identification:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. Paul Mueller Company; Streamline.
2. Labeling product shall be self-laminating cable marker.

3. Cable labeling shall include numeric designation, source, destination, and cable type.

2.27 ACCESSORIES

A. Pneumatic Pressure Gages:

1. Pressure gages shall a 1.5-inch-diameter face for pressures up through 30 psigand 2.5-inch diameter face for greater pressures.
2. Include separate gages for branch pressure and main pressure lines.
3. White dial face with black printing.
4. Include 1-psigincrement for scale ranges through 30 psigand 2-psig increment for larger ranges.
5. Accuracy: Within 1 percent of full-scale range.

B. Pressure Electric Switches:

1. Diaphragm-operated snap acting switch.
2. Set point adjustable from 3 to 20 psig.
3. Differential adjustable from 2 to 6 psig.
4. Rated for resistance loads at 120-V ac.
5. Body and switch housing shall be metal.

C. Damper Blade Limit Switches:

1. Sense positive open and/or closed position of the damper blades.
2. NEMA 250, Type 13, oil-tight construction.
3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

D. Manual Valves:

1. Needle Type:
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) Parker Hannifin Corporation; V series.
   b. PTFE packing.
   c. Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless-steel tubing.
   d. Aluminum T-bar handle.
   e. Include tubing connections.

2. Ball Type:

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) NIBCO INC.; T-580-70-66.

   b. Body: Bronze ASTM B 62 or ASTM B 61.

   c. Ball: Type 316 stainless steel.

   d. Stem: Type 316 stainless steel.

   e. Seats: Reinforced PTFE.

   f. Packing Ring: Reinforced PTFE.

   g. Lever: Stainless steel with a vinyl grip.

   h. 600 WOG.

   i. Threaded end connections.

2.28 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Engraved tag bearing unique identification.

   a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Letter size shall be as follows:

   a. Accessories: Minimum of 0.5 inch high.

   b. Instruments: Minimum of 0.5 inch high.

   c. Control Damper and Valve Actuators: Minimum of Insert dimension 0.5 inch high.

3. Tag shall consist of white lettering on black background.

4. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer.

B. Equipment Warning Labels:

1. Acrylic label with pressure-sensitive adhesive back and peel-off protective jacket.

2. Lettering size shall be at least 14-point type with white lettering on red background.

3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."

2.29 TRANSIENT/SPIKE PROTECTION

A. Suppressors shall be fitted to all controller input points for protection against voltage transients, spikes etc.

B. The communication network(s), shall be isolated against transient disturbances via optical couplers or other approved means. Where running between buildings, lightning protection devices shall be installed on the communications network at the point of entry to each building.

2.30 ELECTROMAGNETIC PROTECTION

A. All components of BAS and the entire BAS system shall comply with the requirements of the relevant Emission and Immunity Standards.

B. In order to avoid corruption of the BAS equipment operation by electrical interference, all wiring shall be installed to minimize coupling of electromagnetic and electrostatic interference on low voltage signals and data wiring. Where mixed wiring is unavoidable braided screen mains cable, dressed close to metalwork, is preferred, but the Tendered shall clearly specify the methods by which he intends to eliminate any such interference with his signal and data transmission.

C. The BAS shall be protected from interference by the operation of hand held radio transmitters, radio pagers, etc. within 1 meter of the equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH EXISTING SYSTEMS

A. Interface with Existing Systems:

1. DDC systems shall interface existing systems to achieve integration.
2. Monitoring and Control of DDC System by Existing Control System:
    a. DDC system performance requirements shall be satisfied when monitoring and controlling DDC system by existing control system.
    b. Operator of existing system shall be able to upload, download, monitor, trend, control and program every input and output point in DDC system from existing control system using existing control system software and operator workstations.
    c. Remote monitoring and control from existing control system shall not require operators of existing control system to learn new software.
    d. Interface of DDC system into existing control system shall be transparent to operators of existing control system and allow operators to program, monitor, and control DDC system from any operator workstation connected to existing control system.
3. Integration of Existing Control System into DDC System:
    a. Existing control system performance requirements shall be satisfied when monitoring and controlling existing control system through DDC system.
    b. Operator shall be able to upload, download, monitor, alarm, report, trend, control and program every input and output point in existing system from DDC system using operator workstations and software provided. The combined systems shall share one database.
    c. Interface of existing control system I/O points into DDC system shall be transparent to operators. All operational capabilities shall be identical regardless of whether I/O already exists or I/O is being installed.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Space mounted devices are to be identical in appearance. All devices shall be mounted under the same style cover.

C. Provide all relays, switches, sources of electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified.

D. Install controls so that adjustments and calibrations can be readily made.

E. Mount surface-mounted control devices on brackets to clear the final finished surface on insulation.

F. Conceal control conduit and wiring in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install control conduit and wiring in parallel banks with all changes in directions made at 90 degree angles.

G. Install control valves horizontally with the power unit up. Installation of control valves will be by the Division 23 Contractor.

H. Unless otherwise noted, install wall mounted sensors, thermostats and humidistats at 5'-0" above the finished floor measured to the centerline of the instrument. Submit device locations, mounting heights and details for approval.

I. Install products level, plumb, parallel, and perpendicular with building construction.

J. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a force.

K. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

L. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

M. Firestop penetrations made in fire-rated assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

N. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 07 9200 "Joint Sealants."

O. Welding Requirements:

1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

P. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

Q. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

R. Corrosive Environments:

1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:

   a. Process exhaust-air streams.

2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Section 26 0533 "Raceways and Boxes for Electrical Systems."

3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 OPERATOR WORKSTATION INSTALLATION

A. Color Graphics Application:

1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's and Architect's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.5 SERVER INSTALLATION

A. Install server(s) at location(s) directed by Owner.

B. Install number of servers required to suit requirements indicated. Review Project requirements and indicate layout of proposed location in Shop Drawings.

C. Install software indicated on server(s) and verify that software functions properly.

D. Develop Project-specific graphics, trends, reports, logs, and historical database.

3.6 GATEWAY INSTALLATION

A. Install gateways if required for DDC system communication interface requirements indicated.

   a. Install gateway(s) required to suit indicated requirements.

   b. Test gateway to verify that communication interface functions properly.

3.7 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface requirements indicated.

   1. Install router(s) required to suit indicated requirements.

B. Test router to verify that communication interface functions properly.

3.8 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply and to UPS units where indicated.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

   1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.

   2. Install controllers in a protected location that is easily accessible by operators.

   3. Top of controller shall be within 72 inches of finished floor.

F. Installation of Programmable Application Controllers:

   1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.

   2. Install controllers in a protected location that is easily accessible by operators.

   3. Top of controller shall be within 72 inches of finished floor.

G. Application-Specific Controllers:

1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.9 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:
   1. Gateways.
   2. Routers.
   3. Controllers.
   4. Electrical power devices.
   5. UPS units.
   6. Relays.
   7. Accessories.

B. Attach wall-mounted enclosures to wall using the following types of steel struts:
   1. For NEMA 250, Type 1 Enclosures: Use galvanized-steel strut and hardware.
   2. For NEMA 250, Type 4 Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
   3. Install plastic caps on exposed cut edges of strut.

C. Align top of adjacent enclosures of like size.

D. Install floor-mounted enclosures located in mechanical equipment rooms on concrete housekeeping pads. Attach enclosure legs using galvanized- steel anchors.

E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.10 ELECTRIC POWER CONNECTIONS

A. Power supply for all control panels handling network, building or primary equipment and for control panels serving emergency and/or critical equipment, locations or points shall be connected via a dedicated BAS circuit to the building Normal/Emergency, Standby-Optional electrical panel. A grounding conductor shall be run from building service entrance panel ground bus. Conductor shall be insulated and isolated from other grounded conductors and building conduit system.

B. Provide power for Application Controllers and all associated control components from nearest applicable electrical control panel or as indicated on the electrical drawings—coordinate with Electrical Contractor.

C. Power for each control panel shall be provided through a switch (standard light switch) located inside the panel. A standard duplex receptacle shall also be provided inside the control panel. The receptacle shall be unswitched.

D. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

E. Comply with requirements in Section 26 2816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

F. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

G. Comply with requirements in Section 26 0533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.11 UNINTERRUPTIBLE POWER SUPPLY

A. Uninterruptible Power Supply(s) shall supply power for the Global Building Controller(s), repeater(s) and/or Application Controllers that monitor or serve emergency and/or critical equipment, locations or points.

B. The UPS shall be equipped with a cord and plug and shall be plugged into a secure outlet. This outlet shall be connected via a dedicated BAS circuit to the building Normal/Emergency, Standby-Optional electrical panel, which may be the same outlet specified above, if applicable.

1. Hard-wiring of UPS not acceptable

C. Signage at the UPS Plug-in location shall include the Electrical Panel Name and Breaker # and shall say: “This outlet for UPS only.”

D. If it is necessary to install the UPS where there is public access, the UPS, the outlet and the UPS plug shall be in a ventilated lockable enclosure. When installed in a space with restricted access (i.e., MER) the UPS, outlet and plug do not need to be in an enclosure.

E. The quantity of UPS devices on a Project shall be minimized to reduce future maintenance issues. The CSC may make suggestions for such to the Professional for consideration.

3.12 IDENTIFICATION

A. The controls contreactor shall label each system device with a point address or other clearly identifiable notation inside the device cover. Labels shall be permanent, and method of labeling shall be approved by the owner.

B. All control equipment shall be clearly identified by control shop drawing designation as follows:

1. Control valves and damper actuators: brass tags or engraved phenolic (“Bakelite”) tags.
2. Other Remote Control Devices: Metal tags or laser printed, adhesive backed, metalized polyester film labels.
3. Control Enclosures and Panels: Engraved nameplate with panel number and system served.

C. Duct static-pressure sensors and piping differential-pressure sensors locations shall be:

1. indicated on the Installation Mark-up Drawings (kept on-site) for transfer of this information onto the As-Builts; and
2. identified on the BAS Floor Plan online graphic; and
3. identified in the building using a label on the nearest ceiling grid, or access-panel where concealed.

D. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 26 0553 "Identification for Electrical Systems" for identification products and installation.

E. Where product is installed above accessible tile ceiling, also install matching engraved phenolic nameplate with identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install engraved phenolic nameplate with identification on face of access door directly below.

3.13 NETWORK INSTALLATION

A. Install fiber-optic cable when connecting between the following network devices and when located in different buildings on campus, or when distance between devices exceeds allowable protocol and medium limits:

1. Operator workstations and network controllers.

B. Install fiber-optic cable when connecting between the following network devices located in same building:

1. Operator workstations and network controllers.

C. Install network cable in continuous raceway.

1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.14 NETWORK NAMING AND NUMBERING

A. The Contractor shall coordinate all point, object naming, and network addressing conventions with the owner before start of work. Unless otherwise indicated by the owner, all point naming conventions shall adhere to tags set out by project haystack guidelines.

B. ASHRAE 135 Networks:

1. MAC Address:
    a. Every network device shall have an assigned and documented MAC address unique to its network.
    b. Ethernet Networks: Document MAC address assigned at its creation.
    c. ARCNET or MS/TP networks: Assign from 00 to 64.
2. Network Numbering:
    a. Assign unique numbers to each new network.
    b. Provide ability for changing network number through device switches or operator interface.
    c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.
3. Device Object Identifier Property Number:
    a. Assign unique device object identifier property numbers or device instances for each device network.
    b. Provide for future modification of device instance number by device switches or operator interface.
    c. LAN shall support up to 4,194,302 unique devices.
4. Device Object Name Property Text:
    a. Device object name property field shall support 32 minimum printable characters.
    b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.
        1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."
        2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".
5. Object Name Property Text for Other Than Device Objects:
    a. Object name property field shall support 32 minimum printable characters.
    b. Assign object name properties with plain-English names descriptive of application.
        1) Example 1: "Zone 1 Temperature."
        2) Example 2 "Fan Start and Stop."
6. Object Identifier Property Number for Other Than Device Objects:
    a. Assign object identifier property numbers according to Drawings indicated.
    b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.

3.15 PIPING AND TUBING INSTALLATION

A. Above-Grade Pneumatic and Air Signal Piping and Tubing Installation:

1. Material Application:

a. Install copper tubing, except as follows:

1) Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing.

2) Concealed Tubing: Polyethylene tubing may be used in lieu of copper tubing when concealed behind accessible ceilings .

b. Install copper tubing, unless other accessible materials are indicated,for pneumatic main and control signals to instruments including, but not limited to, the following:

1) Pneumatic actuators.

2) I/P transducers.

3) Sensors.

4) Switches.

5) Transmitters.

c. Install copper tubing, unless other accessible materials are indicated,for air signals to instruments including, but not limited to, the following:

1) Sensors.

2) Switches.

3) Transmitters.

d. Install barbed fittings to connect polyethylene tubing to instruments, control devices, and accessories.

2. Routing:

a. Do not expose tubing in finished spaces, such as spaces with ceilings; occupied spaces, offices, and conference rooms, unless expressly approved in writing by Architect. Tubing may be exposed in areas without ceilings.

b. Where tubing is installed in finished occupied spaces, install the tubing in surface metal raceway with appropriate fittings only where not feasible to conceal in wall, above ceiling or behind architectural enclosures or covers.

c. Install piping and tubing plumb and parallel to and at right angles with building construction.

d. Install multiple runs of tubing or piping in equally spaced parallel lines.

e. Piping and tubing shall not interfere with access to valves, equipment, duct and equipment access doors, or obstruct personnel access and passageways of any kind.

f. Coordinate with other trades before installation to prevent proposed piping and tubing from interfering with pipe, duct, terminal equipment, light fixtures,

conduit and cable tray space. If changes to Shop Drawings are necessary due to field coordination, document changes on record Drawings.

g. Install vibration loops in copper tubing when connecting to instrument and actuators that vibrate.

3. Support:

   a. According to MSS SP-69, Table 3, except support spacing shall not exceed 60 inches

   b. Support copper tubing with copper hangers, clips, and tube trays.

   c. Do not use tape for support or dielectric isolation.

   d. Install supports at each change in direction and at each branch take off.

   e. Attached supports to building structure independent of work of other trades. Support from ducts, pipes, cable trays, and conduits is prohibited.

   f. Attached support from building structure with threaded rods, structural shapes, or channel strut.

   g. Install and brace supports to carry static load plus a safety margin, which will allow tubing to be serviced.

   h. Brace supports to prevent lateral movement.

   i. Paint steel support members that are not galvanized or zinc coated.

   j. Support polyethylene tubing same as copper tubing.

4. Do not attach piping and tubing to equipment that may be removed frequently for maintenance or that may impart vibration and expansion from temperature change.

5. Joining and Makeup:

   a. Where joining and mating dissimilar metals where galvanic action could occur, install dielectric isolation.

   b. Install a dirt leg with an isolation valve and threaded plug at each main air, connection to a panel, pneumatic pilot positioner and PRV station.

   c. Make threaded joints for connecting to instrument equipment with connectors with a compression tubing connector on one end and threaded connection on other end.

   d. Make tubing bends with a tube-bending tool. Hard bends, wrinkled or flattened bends are unacceptable.

   e. Install tube fittings according to manufacturer's written instructions.

   f. Do not make tubing connections to a fitting before completing makeup of the connection.

   g. Align tubing with the fitting. Avoid springing tube into position, as this may result in excessive stress on both tubing and fitting with possible resulting leaks.

   h. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.

   i. Check tubing for correct diameter and wall thickness.

j. Tube ends shall be cut square and deburred. Exercise care during cutting to keep tubing round.

k. Thread pipe on a threading machine. Ream inner edges of pipe ends, file and grind to remove burrs.

l. Wrap pipe threads of fittings on pneumatic lines with a single wrap of PTFE tape.

m. Protect piping and tubing from entrance of foreign matter.

6. Conduit in which nonmetallic tubing is installed shall not exceed 50 percent fill. Support conduit according to NFPA 70 unless otherwise indicated.

B. Process Tubing Installation:

1. Install process tubing for signal to instruments in liquid and steam systems. Instruments include, but are not limited to, the following:

a. Meters.

b. Sensors.

c. Switches.

d. Transmitters.

2. Support tubing according to MSS SP-69, Table 3, but at intervals no less than 60 inches

3. Install NPS 1/2 process tubing for industrial-grade sensors, transmitters, and switches. Install stainless-steel bushings where required.

4. Make tubing bends with a bending tool. Flattened or wrinkled bends are unacceptable.

5. Support tubing independent of other trades.

6. Route tubing parallel to and at right angles to building construction.

7. Install tubing concealed in areas with ceilings.

8. Install a dirt leg with an isolation valve and threaded plug in drain valve at each connection to a transmitter and switch.

9. Insulate process piping connected to hot water and steam systems for personnel protection if the surface temperature exceeds 120 deg F. Only insulate piping within maintenance personnel reach from floor, platform, or catwalk.

10. Wrap pipe threads of fitting in process tubing with service temperatures below 350 deg F with a single wrap of PTFE tape.

11. Coat pipe threads of fittings on process tubing in services with temperatures exceeding 350 deg F with pipe compound before being made up to reduce the possibility of galling.

12. Do not make tubing connections to a fitting before completing makeup of the connection.

13. Check tubing for correct diameter and wall thickness. Cut the tube ends square and deburred. Exercise care during cutting to keep tubing round.

14. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
15. Align tubing with fitting when installed. Avoid springing tube into position.
16. Install tubing with extreme care exercised to keep foreign matter out of system. Open tubing ends shall be kept plugged to keep out dust, dirt and moisture.
17. Do not attach tubing to equipment that may be removed frequently for maintenance or may impart vibration and expansion from temperature change.

C. Isolation Valves Installation:

1. Install valves full size of piping and tubing.
2. Install isolation valves at the following locations:
   a. Process connection.
   b. Inlet to each instrument including, sensors, transmitters, switches, gages, and other control devices.
   c. At both sides of every motorized control valve, not already enclosed by device/equipment isolation valves.
3. Locate valves to be readily accessible from floor.

3.16 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Comply with TIA 568-C.1.

C. Wiring Installation:

Service	Control Wiring Type
Backbone, any peer-to-peer, Incoming Service	EMT
Exposed in labs, offices, corridors, above baffles etc., below 8’ AFF	EMT
Exposed in Robotics	EMT
Concealed (above drop/GWB ceilings, in wall etc.)	Plenum Rated Cable*
Mechanical and Equipment Rooms	EMT
Loading Dock	EMT

*For all wiring within new wall construction, provide steel EMT from the wall mounted sensor/thermostat as required to reach the ceiling cavity.

D. Wiring Method:
1. Cables for 120/24 VAC wiring and low level signal wiring shall always be run in separate raceways.
2. Wire splices within conduit are prohibited under any circumstances.
3. All Fire Alarm System Relay and Monitoring Module wiring shall be in accordance with Division 26.
4. All wiring shall be in accordance with this specification and Division 26, including tagging, labeling and identification.

5. Controllers shall be provided with a terminal strip for field wiring. All control wiring internal to the panel landing direct on I/O will be done through a terminal strip. Under no circumstances will field wiring be terminated from inputs or outputs direct to the I/O controllers.
6. Line voltage wiring, concealed or exposed, shall be installed in accordance with Division 26.
7. Comply with requirements for raceways and boxes specified in Section 26 0533 "Raceways and Boxes for Electrical Systems."
8. Comply with requirements for cable trays specified in Section 26 0536 "Cable Trays for Electrical Systems."

E. Field Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

F. Conduit Installation:

1. Install conduit expansion joints where conduit runs exceed 200 feet, and conduit crosses building expansion joints.
2. Coordinate conduit routing with other trades to avoid conflicts with ducts, pipes and equipment and service clearance.
3. Maintain at least 3-inchseparation where conduits run axially above or below ducts and pipes.
4. Limit above-grade conduit runs to 100 feet without pull or junction box.
5. Do not install raceways or electrical items on any "explosion-relief" walls, or rotating equipment.
6. Do not fasten conduits onto the bottom side of a metal deck roof.
7. Flexible conduit is permitted only where flexibility and vibration control is required.
8. Limit flexible conduit to 3 feet long.
9. Conduit shall be continuous from outlet to outlet, from outlet to enclosures, pull and junction boxes, and shall be secured to boxes in such manner that each system shall be electrically continuous throughout.
10. Direct bury conduits underground or install in concrete-encased duct bank where indicated.
    a. Use rigid, nonmetallic, Schedule 80 PVC.
    b. Provide a burial depth according to NFPA 70, but not less than 24 inches.
11. Secure threaded conduit entering an instrument enclosure, cabinet, box, and trough, with a locknut on outside and inside, such that conduit system is electrically continuous throughout. Provide a metal bushing on inside with insulated throats. Locknuts shall be the type designed to bite into the metal or, on inside of enclosure, shall have a grounding wedge lug under locknut.
12. Conduit box-type connectors for conduit entering enclosures shall have an insulated throat.

13. Connect conduit entering enclosures in wet locations with box-type connectors or with watertight sealing locknuts or other fittings.
14. Offset conduits where entering surface-mounted equipment.
15. Seal conduit runs used by sealing fittings to prevent the circulation of air for the following:
    a. Conduit extending from interior to exterior of building.
    b. Conduit extending into pressurized duct and equipment.
    c. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.

G. Wire and Cable Installation:

1. Cables serving a common system may be grouped in a common raceway. Install control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
2. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
    a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
3. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
5. UTP Cable Installation:
    a. Comply with TIA 568-C.2.
    b. Do not untwist UTP cables more than 1/2 inchfrom the point of termination, to maintain cable geometry.
6. Installation of Cable Routed Exposed under Raised Floors:
    a. Install plenum-rated cable only.
    b. Install cabling after the flooring system has been installed in raised floor areas.
7. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.
8. Provide strain relief.
9. Terminate wiring in a junction box.
10. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.

11. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
12. Keep runs short. Allow extra length for connecting to terminal boards. Do not bend flexible coaxial cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
13. Ground wire shall be copper and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.
14. Wire and cable shall be continuous from terminal to terminal without splices.
15. Use insulated spade lugs for wire and cable connection to screw terminals.
16. Use shielded cable to transmitters.
17. Use shielded cable to temperature sensors.
18. Perform continuity and meager testing on wire and cable after installation.
19. Do not install bruised, kinked, scored, deformed, or abraded wire and cable. Remove and discard wire and cable if damaged during installation, and replace it with new cable.

3.17 FIELD QUALITY CONTROL

A. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use a fiber-optic time domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.18 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. For pneumatic products, verify that air supply for each product is properly installed.

F. Control Damper Checkout:

1. For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.
2. Verify that control dampers are installed correctly for flow direction.
3. Verify that proper blade alignment, either parallel or opposed, has been provided.
4. Verify that damper frame attachment is properly secured and sealed.
5. Verify that damper actuator and linkage attachment is secure.
6. Verify that actuator wiring is complete, enclosed and connected to correct power source.
7. Verify that damper blade travel is unobstructed.

G. Control Valve Checkout:

1. For pneumatic valves, verify that pressure gages are provided in each air line to valve actuator and positioner.
2. Verify that control valves are installed correctly for flow direction.
3. Verify that valve body attachment is properly secured and sealed.
4. Verify that valve actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that valve ball, disc or plug travel is unobstructed.
7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

H. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.

4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:
   a. Verify sensing element type and proper material.
   b. Verify length and insertion.

3.19 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. Test instrument accuracy

Temperature:	1/4°F or 1/2% full scale, whichever is less.
High Pressure (psi):	1/2 psi or 1/2% full scale, whichever is less.
Low Pressure (in w.c.):	1/2% of full scale
Humidity:	2% RH
Electrical:	1/4% full scale

D. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

E. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

F. Provide diagnostic and test equipment for calibration and adjustment.

G. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

H. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

I. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

J. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

K. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

L. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

M. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

O. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

P. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

Q. Switches: Calibrate switches to make or break contact at set points indicated.

R. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.20 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.21 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

a. Upper quarter of range.

b. Lower quarter of range.

c. At midpoint of range.

8. Exercise each binary point.

9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.

10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.22 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.

2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.

3. HVAC equipment motors operate below full-load amperage ratings.

4. Required DDC system components, wiring, and accessories are installed.

5. Installed DDC system architecture matches approved Drawings.

6. Control electric power circuits operate at proper voltage and are free from faults.

7. Required surge protection is installed.

8. DDC system network communications function properly, including uploading and downloading programming changes.

9. Using BACnet protocol analyzer, verify that communications are error free.

10. Each controller's programming is backed up.

11. Equipment, products, tubing, wiring cable and conduits are properly labeled.

12. All I/O points are programmed into controllers.

13. Testing, adjusting and balancing work affecting controls is complete.

14. Dampers and actuators zero and span adjustments are set properly.

15. Each control damper and actuator goes to failed position on loss of power.

16. Valves and actuators zero and span adjustments are set properly.

17. Each control valve and actuator goes to failed position on loss of power.

18. Meter, sensor and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.
    a. Verify communication with each field point.
    b. Verify analog I/O points at operating value.
    c. Make adjustments to out-of-tolerance I/O points.
        1) Identify I/O points for future reference.
        2) Simulate abnormal conditions to demonstrate proper function of safety devices.
        3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.
2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. Alarm reporting, alarm acknowledgement, avoidance of nuisance alarms, inhibition of alarms for devices out of service, shutdown, etc, shall be demonstrated.

5. After 24 Hours following Initial Validation Test:
   a. Re-check I/O points that required corrections during initial test.
   b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Network Bandwidth Test:
1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.

3.23 FINAL REVIEW

A. Submit written request to Architect and Construction Manager when DDC system is ready for final review. Written request shall state the following:
1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Review by Architect and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Prepare and submit closeout submittals and begin procedures indicated in "Extended Operation Test" Article when no deficiencies are reported.

E. A part of DDC system final review shall include a demonstration to parties participating in final review.
1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.

2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.

3. Demonstration shall include, but not be limited to, the following:

   a. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 20 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.

   b. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.

   c. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.

   d. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.

   e. Trends, summaries, logs and reports set-up for Project.

   f. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.

   g. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.

   h. Software's ability to edit control programs off-line.

   i. Data entry to show Project-specific customizing capability including parameter changes.

   j. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.

   k. Execution of digital and analog commands in graphic mode.

   l. Spreadsheet and curve plot software and its integration with database.

   m. Online user guide and help functions.

   n. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.

   o. System speed of response compared to requirements indicated.

3.24 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.25 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for one year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within one year(s) from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.26 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.

2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.

3. Minimum Training Requirements:

a. Provide not less than five days of training total.

b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.

c. Total days of training shall be broken into not more than two separate training classes.

C. Training proposal:

1. Prior to completion of commissioning a formal training proposal defining scope and objectives and training schedule shall be submitted by the BAS contractor. Training will typically be divided between System Managers and General Users. The training content detailed below for each user type shall be coordinated with the owner. The training program shall utilize components, hardware, software and documentation customized for the project.

2. The formal proposal shall include:

a. Course title

b. Summary of course scope and objectives

c. Recommended attendees

d. Maximum number of attendees per session

e. Number and duration of sessions

D. Training Schedule:

1. Schedule training with Owner 20 business days before expected Substantial Completion.
2. Schedule training to provide Owner with at least 20 business days of notice in advance of training.
3. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session shall be split in half with 30-minute break between sessions. Morning and afternoon sessions shall be separated by 60 -minute lunch period. Training, including breaks and excluding lunch period, shall not exceed eighthours per day.
4. Provide staggered training schedule as requested by Owner.

E. Training Attendee List and Sign-in Sheet:

1. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.
2. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Preprinted sign-in sheet shall include training session number, date and time, instructor name, phone number and e-mail address, and brief description of content to be covered during session. List attendees with columns for name, phone number, e-mail address and a column for attendee signature or initials.
4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5. At end of each training day, send Owner an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.

F. Training Attendee Headcount:

1. Plan in advance of training for five attendees.
2. Make allowance for Owner to add up to two attendee(s) at time of training.
3. Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

G. Attendee Training Manuals:

1. Provide each attendee with a color hard copy of all training materials and visual presentations.
2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.

3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

H. Instructor Requirements:

1. One or multiple qualified instructors, as required, to provide training.
2. Instructors shall have not less than five years of providing instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

I. Organization of Training Sessions:

1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
   a. Daily operators.
   b. Advanced operators.
   c. System managers and administrators.
2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.

J. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

K. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.

5. Operating operator workstations, printers and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
17. Executing digital and analog commands in graphic mode.
18. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
19. Demonstrating DDC system performance through trend logs and command tracing.
20. Demonstrating scan, update, and alarm responsiveness.
21. Demonstrating spreadsheet and curve plot software, and its integration with database.
22. Demonstrating on-line user guide, and help function and mail facility.
23. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
24. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
    a. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
    b. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.
    c. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.

d. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

L. Training Content for Advanced Operators:

1. Making and changing workstation graphics.
2. Creating, deleting and modifying alarms including annunciation and routing.
3. Creating, deleting and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
4. Creating, deleting and modifying reports.
5. Creating, deleting and modifying points.
6. Creating, deleting and modifying programming including ability to edit control programs off-line.
7. Creating, deleting and modifying system graphics and other types of displays.
8. Adding DDC controllers and other network communication devices such as gateways and routers.
9. Adding operator workstations.
10. Performing DDC system checkout and diagnostic procedures.
11. Performing DDC controllers operation and maintenance procedures.
12. Configuring DDC system hardware including controllers, workstations, communication devices and I/O points.
13. Maintaining, calibrating, troubleshooting, diagnosing and repairing hardware.
14. Adjusting, calibrating and replacing DDC system components.

M. Training Content for System Managers and Administrators:

1. DDC system software maintenance and backups.
2. Uploading, downloading and off-line archiving of all DDC system software and databases.
3. Interface with Project-specific, third-party operator software.
4. Understanding password and security procedures.
5. Adding new operators and making modifications to existing operators.
6. Operator password assignments and modification.
7. Operator authority assignment and modification.
8. Workstation data segregation and modification.

N. Video of Training Sessions:

1. Provide a digital video and audio recording of each training session. Create a separate recording file for each session.
2. Stamp each recording file with training session number, session name and date.

3. Provide Owner with two copies of digital files on DVDs or flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

End of Section

Section 23 09 23.11

CONTROL VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes control valves and actuators for DDC systems.

B. Related Requirements:

1. Section 230923 "Direct Digital Control (DDC) System for HVAC" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993.11 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.11.

1.3 DEFINITIONS

A. Cv: Design valve coefficient.

B. DDC: Direct-digital control.

C. NBR: Nitrile butadiene rubber.

D. PTFE: Polytetrafluoroethylene

E. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for pneumatic signal and main air tubing.

C. Delegated-Design Submittal:

1. Schedule and design calculations for control valves and actuators, including the following:

a. Flow at project design and minimum flow conditions.
b. Pressure differential drop across valve at project design flow condition.
c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Control valve installation location shown in relationship to room, duct, pipe, and equipment.
2. Size and location of wall access panels for control valves installed behind walls.
3. Size and location of ceiling access panels for control valves installed above inaccessible ceilings.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control valves to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.

D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

E. Backup Power Source: Systems and equipment served by a backup power source shall have associated control valve actuators served from a backup power source.

F. Environmental Conditions:
1. Provide electric control valve actuators, with protective enclosures, including supplemental heat and cooling where necessary to ensure proper protection from the installed location environment.

G. Determine control valve sizes and flow coefficients by ISA 75.01.01.

H. Control valve characteristics and rangeability shall comply with ISA 75.11.01.

I. Selection Criteria:

1. Control valve shutoff classifications shall be FCI 70-2, Class IV or better unless otherwise indicated.

2. Control valve close-off pressure shall be greater than or equal to the total head of the pump of the associated hydronic system.
3. Valve pattern, three-way or straight through, shall be as indicated on Drawings.
4. Modulating straight-through pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
5. Modulating three-way pattern water valves shall have linear flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position.
6. Modulating butterfly valves shall have equal percentage flow-throttling characteristics, and shall be high performance butterfly valves.
7. Fail positions unless otherwise indicated:

   a. Chilled Water: Closed
   b. Condenser Water: Last position.
   c. Heating Hot Water in AHU’s: Open.
   d. Terminal unit Hot Water: Last position

e. Steam: Close.

8. Globe-type control valves shall pass the design flow required with not more than 95 percent of stem lift unless otherwise indicated.
9. Rotary-type control valves, such as ball and butterfly valves, shall have Cv falling between 65 and 75 degrees of valve full open position and minimum valve Cv between 15 and 25 percent of open position.
10. Selection shall consider viscosity, flashing, and cavitation corrections.
11. Valves shall have stable operation throughout full range of operation, from design to minimum Cv.
12. Minimum Cv shall be calculated at 10 percent of design flow, with a coincident pressure differential equal to the system design pump head.
13. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of 4 psig at design flow unless otherwise indicated.
14. Modulating valve sizes for steam service shall provide a pressure drop at design flow equal to lesser of the following:
    a. 50 percent of the absolute steam pressure at the valve inlet.
15. Two-position control valves shall be line size unless otherwise indicated.
16. In steam systems, use ball- or globe-style control valves regardless of size.

2.2 BALL-STYLE CONTROL VALVES

A. Ball Valves with Two Ports and Characterized Disk:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:

    a. Belimo

    b. Valve Solutions
2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 deg F.
6. Body and Tail Piece: Cast bronze ASTM B61, ASTM B62, ASTM B584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: 300 series stainless steel.
9. Stem and Stem Extension:

    a. Material to match ball.
    b. Blowout-proof design.
    c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.

12. Flow Characteristics for A-Port: Equal percentage.
13. Flow Characteristics for B-Port: Modified for constant common port flow.

B. Chilled Water Recirculating Loop Valve:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:

   a. Fisher

   b. Neles

   c. Valve Solutions. Inc.
2. Body and Tail Piece: Flanged carbon steel
3. Seat: composition or stainless/Teflon
4. Leakage Class: ANSI Class IV, minimum
5. Trim: 316 Stainless
6. Flow Characteristic: Equal percentage or modified equal
7. Fail: spring open
8. CV shall be selected for a 2 PSI drop at the maximum building flow with a valve at the 90% open CV.
9. Valve shall seatagainst 40 PSI differential pressure

2.3 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

1. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:

   a. Belimo

B. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

C. Actuators for Steam Control Valves: Shutoff against 1.2 times steam design pressure.

D. Position indicator and graduated scale on each actuator.

E. Type: Motor operated, with or without gears, electric and electronic.

F. Voltage: Voltage selection delegated to professional designing control system.

G. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

H. Function properly within a range of 85 to 120 percent of nameplate voltage.

I. Construction:

1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.

2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

J. Field Adjustment:

1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

K. Two-Position Actuators: Single direction, spring return or reversing type.

L. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

    a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
    b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.
    c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
    d. Programmable Multi-Function:

        1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
        2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
        3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

M. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

N. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.

2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

O. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

P. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

Q. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

R. Stroke Time:

1. Operate valve from fully closed to fully open within 75 seconds.
2. Operate valve from fully open to fully closed within 75 seconds.
3. Move valve to failed position within 15 seconds.
4. Select operating speed to be compatible with equipment and system operation.

S. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

2.4 STEAM CONTROL VALVES

A. Basis of Design Product: Subject to compliance with requirements, provide product by one of the following:
1. Fisher
2. Neles
3. Valve Solution (VSI)

B. Actuator: Belimo Electric

C. Temperature Rating : 400 deg F or Higher

D. Type: High performance segmented V-ball type

E. Leakage Class: ANSI Class V

F. Flow Characteristic: Equal Percentage

G. Turndown: 300:1

H. On steam valves with a normal dP of 15 psig or greater, stainless steel noise reducing trim is required.

I. Normally closed spring return: Heat exchangers, converters, clean steam systems, and humification systems.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL VALVE APPLICATIONS

A. Chilled water recirculating loop valve: Chilled water recirculating loop valve

B. Two-position operation NPS 2 and Smaller: Ball valve with single port and characterized disk or globe-style.

C. Modulating operation NPS 2 and Smaller: Ball valve with single port and characterized disk or globe-style.

D. Two-position operation NPS 2-1/2” and greater: High performance butterfly valve.

E. Modulating operation NPS 2-1/2” and greater: High performance butterfly valve.

F. Three-position operation: three-position globe valves.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a 20 lb force.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including. but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.

1. For all control valves where isolation is not already provided as part of the coil/equipment assembly.

D. Valve Orientation:

1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.
4. Install all valves according to manufacturer’s instructions.

E. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

F. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

G. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.6 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with valve identification on valve.

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.9 CHECKOUT PROCEDURES

A. Control Valve Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner.
6. Verify that control valves are installed correctly for flow direction.
7. Verify that valve body attachment is properly secured and sealed.
8. Verify that valve actuator and linkage attachment are secure.
9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
10. Verify that valve ball, disc, and plug travel are unobstructed.

11. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

End of Section

Section 23 09 23.12

CONTROL DAMPERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following types of control dampers and actuators for DDC systems:

1. Rectangular control dampers.
2. Round control dampers.
3. General control-damper actuator requirements.
4. Pneumatic actuators.
5. Electric and electronic actuators.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.12.

1.3 DEFINITIONS

A. DDC: Direct-digital control.

B. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each

unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Include diagrams for pneumatic signal and main air tubing.

C. Delegated-Design Submittal:

1. Schedule and design calculations for control dampers and actuators, including the following.
   a. Maximum close-off pressure.
   b. Leakage airflow at maximum system pressure differential (fan close-off pressure).
   c. Torque required at worst case condition for sizing actuator.
   d. Actuator selection indicating torque provided.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Product installation location shown in relationship to room, duct, and equipment.
2. Size and location of wall access panels for control dampers and actuators installed behind walls.
3. Size and location of ceiling access panels for control dampers and actuators installed above inaccessible ceilings.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Delegated Design: Engage a qualified professional engineer as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.

D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

E. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.

F. Environmental Conditions:

1. Provide electric control-damper actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control-damper actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.

    a. Hazardous Locations: Explosion-proof rating for condition.

G. Selection Criteria:

1. Fail positions unless otherwise indicated:

    a. Supply Air: Last position.
    b. Return Air: Last position.
    c. Outdoor Air: Close.
    d. Mixed Air: Open.
    e. Exhaust Air: Close.

2. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
3. Select modulating dampers for a pressure drop of 2 percent of fan total static pressure unless otherwise indicated.
4. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.
5. Wherever possible, dampers shall have external crankshafts to allow the connection of the damper actuator outside of the airstream.

2.2 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
3. Dampers shall be manufactured by:
   a. Belimo

B. Rectangular Dampers with Aluminum Airfoil Blades:
   1. Performance:

      a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
      b. Pressure Drop: 0.05-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
      c. Velocity: Up to 6000 fpm.
      d. Temperature: Minus 40 to plus 185 deg F.
      e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
      f. Damper shall have AMCA seal for both air leakage and air performance.

   2. Construction:

      a. Frame:

         1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.
         2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
         3) Width not less than 5 inches.

      b. Blades:

         1) Hollow, airfoil, extruded aluminum.
         2) Parallel or opposed blade configuration as required by application.
         3) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.07 inch thick.
         4) Width not to exceed 6 inches.
         5) Length as required by close-off pressure, not to exceed 48 inches.

      c. Seals:

         1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
         2) Jambs: Stainless steel, compression type.

      d. Axles: 0.5-inch- diameter plated steel, mechanically attached to blades.
      e. Bearings:

1) Molded synthetic or stainless-steel sleeve mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

C. Rectangular Dampers with Steel Airfoil Blades:

1. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
b. Pressure Drop: 0.06-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 6000 fpm.
d. Temperature: Minus 40 to plus 185 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM A 653/A 653M galvanized-steel profiles, 0.06 inch thick.
2) Hat-shaped channel with integral flanges. Mating face shall be a minimum of 1 inch.
3) Width not less than 5 inches.

b. Blades:

1) Hollow, airfoil, galvanized steel.
2) Parallel or opposed blade configuration as required by application.
3) Material: ASTM A 653/A 653M galvanized steel, 0.05 inch thick.
4) Width not to exceed 6 inches.
5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- diameter plated steel, mechanically attached to blades.
e. Bearings:

1) Stainless steel mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide epoxy finish for surfaces in contact with airstream.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

D. Insulated Rectangular Dampers:

1. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure and shall not exceed 4.9 cfm/sq. ft. against 4-in. wg differential static pressure at minus 40 deg F.
b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 100 to plus 185 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

   a. Frame:

      1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.08 inch thick.
      2) C-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
      3) Width not less than 4 inches.
      4) Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.
      5) Damper frame shall be insulated with polystyrofoam on four sides.

   b. Blades:

      1) Hollow shaped, extruded aluminum.
      2) Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
      3) Parallel or opposed blade configuration as required by application.
      4) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.08 inch thick.
      5) Width not to exceed 6 inches.
      6) Length as required by close-off pressure, not to exceed 48 inches.

   c. Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the aluminum extrusions.
   d. Axles: 0.44-inch- diameter plated steel, mechanically attached to blades.
   e. Bearings:

      1) Bearings shall be composed of a Celcon inner bearing fixed to axle, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
      2) Where blade axles are installed in vertical position, provide thrust bearings.

   f. Linkage:

      1) Concealed in frame.
      2) Constructed of aluminum and plated steel.
      3) Hardware: Stainless steel.

   g. Transition:

      1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
      2) Factory mount damper in a sleeve with a close transition to mate to field connection.
      3) Damper size and sleeve shall be connection size plus 2 inches.
      4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
      5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

2.3 ROUND CONTROL DAMPERS

A. Round Dampers, Sleeve Type:

1. Dampers shall be manufactured by:
Belimo

2. Performance:

a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Pressure Drop: 0.02-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 25 to plus 200 deg F.
e. Pressure Rating: 8-in. wg for sizes through 12 inches, 6-in. wg for larger sizes.

3. Construction:

a. Frame:

1) Material: galvanized steel, 0.04 in thick.
2) Outward rolled stiffener beads positioned approximately 1 inch inboard of each end.
3) Sleeve-type connection for mating to adjacent ductwork.
4) Size Range: 4 to 24 inches.
5) Length not less than 7 inches.
6) Provide 2-inch sheet metal stand-off for mounting actuator.

b. Blade: Double-thickness circular flat blades sandwiched together and constructed of galvanized steel.
c. Blade Seal: Polyethylene foam seal sandwiched between two sides of blades and fully encompassing blade edge.
d. Axle: 0.5-inch- diameter plated steel, mechanically attached to blade.
e. Bearings: Stainless-steel sleeve pressed into frame.

B. Round Dampers, Flanged Type:

1. Performance:

a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Pressure Drop: 0.03-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.

d. Temperature: Minus 25 to plus 250 deg F.
e. Pressure Rating: 8-in. wg for sizes through 36 inches in diameter, 6-in. wg for larger sizes.

2. Construction:

a. Frame:

1) Size Range: 4 to 60 inches.
2) Material: galvanized steel.

a) Sizes through 24 Inches in Diameter: 0.15 inch thick.
b) Sizes 26 through 48 Inches in Diameter: 0.25 inch thick.
c) Larger Sizes: 0.31 inch thick.

3) Flanges:

a) Outward rolled with bolt holes on each end of frame for mating to adjacent ductwork.
b) Face: Not less than 1.25 inch for damper sizes through 12 inches in diameter, 1.5 inch for damper sizes 14 through 24 inches in diameter, and 2 inches for larger sizes.

4) Length (Flange Face to Face): Not less than 8 inches.
5) Provide 3-inch sheet metal stand-off for mounting actuator.

b. Blade: Reinforced circular flat blade constructed of galvanized steel.

1) Sizes through 24 Inches: 0.15 inch thick.
2) Sizes 26 through 48 Inches: 0.19 inch thick.
3) Larger Sizes: 0.25 inch thick.

c. Blade Stop: Full circumference, located in airstream, minimum 0.5 by 0.25 inch galvanized steel bar.
d. Blade Seal: Neoprene, mechanically attached to blade and fully encompassing blade edge.
e. Axle: plated steel, mechanically attached to blade.

1) Sizes through 14 Inches: 0.5 inch in diameter.
2) Sizes 16 through 42 Inches: 0.75 inch in diameter.
3) Larger Sizes: 1 inch in diameter.

f. Bearings: Stainless-steel sleeve pressed into frame.

2.4 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Use of multiple actuators is not allowed.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

2.5 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Actuators shall be manufactured by one of the following:
   1. Belimo

C. Voltage:

   1. Voltage selection is delegated to professional designing control system. Controls contractor shall provide control power transformers for damper actuators for low voltage operation as required.
   2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
   3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

D. Construction:

   1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
   2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
   3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

E. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

F. Two-Position Actuators: Single direction, spring return or reversing type.

G. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

    a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
    b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10-V or 2- to 10-V dc and 4- to 20-mA signals.
    c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink or source controller.

H. Position Feedback:

1. Equip Where indicated, two-position actuators with limit switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Where indicated, equip modulating actuators with true position feedback for monitoring the status of the valve. Re-transmission of the control signal is not acceptable.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

I. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

J. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

K. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.

2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

L. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

M. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

N. Stroke Time:

1. Operate damper from fully closed to fully open within 60 seconds.
2. Operate damper from fully open to fully closed within 60 seconds.
3. Move damper to failed position within 15 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

O. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:

1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

G. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 15 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.5 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine

continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with damper identification on damper.

3.7 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.
6. Verify that control dampers are installed correctly for flow direction.
7. Verify that proper blade alignment, either parallel or opposed, has been provided.
8. Verify that damper frame attachment is properly secured and sealed.
9. Verify that damper actuator and linkage attachment are secure.
10. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
11. Verify that damper blade travel is unobstructed.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

End of Section

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Section 23 09 23.13

ENERGY METERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes thermal and electric power energy meters that connect to DDC systems.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.13.

1.3 DEFINITIONS

A. DDC: Direct-digital control.

B. Ethernet: Local area network based on IEEE 802.3.1 standards.

C. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

D. I/O: Input/output.

E. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

F. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

G. RS-485: A TIA standard for multipoint communications using two twisted pairs.

H. RTD: Resistance temperature detector.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating electrical power requirements.
3. Product description with complete technical data, performance curves, and product specification sheets.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For energy meters to include in operation and maintenance manuals.

B. Verification test report: Test report indicating verification of meter calibration and reporting values.

PART 2 - PRODUCTS

2.1 THERMAL ENERGY METERS

A. Performance Requirements: Manufacturer shall certify that each energy meter indicated complies with specified performance requirements and characteristics.

1. Product certificates are required.

B. Insertion-Type Thermal Energy Meters:
1. Thermal energy meters shall be manufactured by one of the following:
   a. Onicon System 10
   b. Or approved equal
2. Description:

a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, pressure transmitter(for steam service), keypad user interface, installation hardware, color-coded interconnecting cabling, and installation instructions.
b. Each thermal energy meter shall be individually calibrated and provided with calibration certification traceable to NIST.

3. Alphanumeric display of the following on face of enclosure:

a. Total energy consumption.
b. Energy rate.
c. Flow rate.
d. Supply temperature.
e. Return temperature.
f. Visual indication of power status (on/off) on face of enclosure.

4. Electronics Enclosure:

a. Remote from temperature and flow sensors.
b. NEMA 250, Type 12 or Type 13 for indoor applications and NEMA 250, Type 4 or Type 4X for outdoor applications.
c. Labeled terminal strip for field wiring connections.

5. Programming:

a. Factory programmed for specific application and field programmable through keypad on face of enclosure.
b. Programmed parameters and total energy consumption shall be stored in non-volatile EEPROM memory.

6. Output Signals:

a. Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50-V rating and contact duration of 0.5, 1, 2, or 6 seconds.
b. Energy Rate, Flow Rate, Supply Temperature, Return Temperature, pressure: 4 to 20 mA or zero- to 10-V dc for each.

7. Serial Communication Interface: BACnet IP
8. Temperature Sensors:

a. RTD, 1,000 Ohm with 6” well, temperature range matched to application.
b. Differential temperature accuracy within 0.15 deg F over the calibrated range.
c. NEMA 250, Type 4 junction box with thermal isolation.
d. Stainless-steel thermowell with NPS 1/2 NPT connection for each sensor.

9. Flow Sensor:

a. Suitable for an operating pressure of at least 200 psig.
b. Meters in hot-water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F.

c. Pressure drop not to exceed 1 psig at 20-fps flow velocity in NPS 2 pipe and decreasing in large pipe with lower velocity.
d. Sensor Accuracy:

1) Within 1 percent of actual flow between the flow velocity range of 3 to 30 fps.
2) Within 2 percent of actual flow between the flow velocity range of 0.4 to 20 fps.
3) Within 0.5 percent of actual reading at the calibrated velocity.

e. Wet calibrate and tag each sensor to standards traceable to NIST, and provide each sensor with a certificate of calibration.
f. Provide single turbine sensors for pipe size NPS 2 and smaller. Provide dual turbine sensors for pipe size NPS 2-1/2 and larger. Provide bidirectional dual turbine sensors where installed in bypass piping.
g. For sensors with dual contra-rotating turbine elements, provide each turbine element with its own rotational sensing system and an averaging circuit to reduce measurement errors due to a poor flow profile.
h. Rotational sensing of each turbine shall be accomplished electronically by sensing impedance change. The sensor shall have an integral frequency output linear with flow rate and individual top and bottom turbine outputs for diagnostic purposes.
i. Provide the flow sensor complete with installation hardware necessary to enable insertion and removal from the pipe without system shutdown.
j. Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts. Construct wetted metal components of Type 316 stainless steel, including the installation hardware.
k. House the sensor electronics in a NEMA 250, Type 4 weathertight aluminum enclosure with a gasketed cover. Housing shall include connection for field-installed conduit.
l. Sensor cable length shall be sufficient to connect to display module.
m. Sensor housing shall have full-port Type 316 stainless-steel ball valve for system isolation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

C. Support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a 20 lb force.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 Quality Assurance

A. All metering to be installed, functional, and fully tested before services are turned on to the building.

B. Field and System Tests
   1. BAS interface test to be conducted to demonstrate:
      a. Communication verification to each field point
      b. Testing of communications to the BAS network and campus network (if applicable). EOR and owner to be notified minimum of 2 weeks before proposed testing.
   2. Meter Data Confirmation
      a. Verify flow through service line equates to meter reported values
      b. Verify flow data values received into metering database are substantiated by field results at meter.
      c. Verification devices to have equal or superior accuracy to installed sensors.
      d. Verification report to be submitted to EOR.

3.5 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper energy meter operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

End of Section

Section 23 09 23.14

FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Airflow sensors.
2. Airflow switches.
3. Airflow transmitters.
4. Liquid flow meters.
5. Liquid flow sensors.
6. Liquid flow switches.
7. Liquid flow transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.14.

1.3 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

C. PEEK: polyetheretherketone.

D. PTFE: Polytetrafluoroethylene.

E. PPS: Polyphenylene sulfide.

F. RS-485: A TIA standard for multipoint communications using two twisted pairs.

G. RTD: Resistance temperature detector.

H. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Delegated-Design Submittal:

1. Schedule and design calculations for flow instruments, including the following.

a. Flow at Project design and minimum flow conditions.
b. Pressure drop at Project design and minimum flow conditions.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

B. Product Test Reports: For each product, for tests performed by a qualified testing agency.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Provide parts, as indicated by manufacturer's recommended parts list, for product operation during two-year period following warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

A. Air sensors and transmitters shall have an extended range of 20 percent above Project design flow and 20 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

B. Liquid and steam sensors, meters, and transmitters shall have an extended range of 20 percent above Project design flow and 20 percent below Project minimum flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

2.3 AIRFLOW SENSORS:

A. Performance Requirements:

1. Adjustable for changes in system operational parameters.
2. Airflow Sensor and Transmitter Range: Extended range between 0 and 5000 fpm air velocity.
3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.

    a. Product certificates are required.

B. Pitot-Tube Airflow Sensor Station:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Air Monitor Corporation.

    b. Paragon
2. Description: Multiple total- and static-pressure sensors positioned at the center of equal area of the station cross section and interconnected by respective averaging manifolds.

    a. Stations 4 sq. ft. and Smaller: One total-pressure sensor and one static-pressure sensor for every 16 sq. in. of station area.
    b. Stations Larger than 4 sq. ft.: One total-pressure sensor and one static-pressure sensor for every 36 sq. in. of station area.

3. Casing: Galvanized sheet steel at least 0.079 inch thick with coating complying with ASTM A 653/A 653M, G90. Casings shall be stainless steel, 0.0781 inch thick, when connected to stainless duct and aluminum, 0.063 inch thick, when connected to aluminum duct.

    a. Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with aluminum paint.
    b. Casing Depth: At least 8 inches.
    c. Casing Flanges: Outward flange, minimum flange face 1.5 inches.
    d. Casing Configuration and Size: Match shape (rectangular, round, flat oval) and same size as adjacent duct unless otherwise indicated.

4. Include an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to casing.

    a. Construct straightener or equalizer from Type 3003 aluminum or Type 316 stainless steel, depending on casing material. Use stainless steel for units with stainless-steel casings.

5. Construct pressure sensor array from drawn copper or stainless-steel tubing. Use stainless steel for units with stainless-steel casings. Copper tubing shall comply with ASTM B 75 and ASTM B 280. Minimum tube wall thickness shall be 0.030 inch. Include internal piping and external pressure transmitter ports.
6. Station Labeling: Identification label on each station casing indicating model number, size, area, and application-specific airflow range.
7. Performance:

    a. Pressure Loss: 0.015-inch wg at 1000 fpm, or 0.085-inch wg at 2000 fpm.
    b. Accuracy: Within 2 percent of actual airflow.
    c. Self-Generated Sound: NC 40 and sound level within the duct shall not be amplified.
    d. Performance rated and tested according to AMCA 610. Each station shall bear the AMCA seal.

C. Pitot-Tube Fan Inlet Airflow Traverse Sensor:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Air Monitor Corporation.

    b. Paragon
2. Traverse manifold designed for mounting in fan inlets.
3. Contain multiple total- and static-pressure sensors placed at concentric area centers along the exterior surface of cylindrical manifold and internally connected to their respective averaging manifolds. Sensors shall not protrude beyond the surface of the manifold nor be adversely affected by particle contamination present in airstream.
4. Manifold (two per inlet) shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings.
5. Sensors shall be capable of producing steady, non-pulsating signals of standard total- and static-pressure without need for flow corrections or factors, with an accuracy of 3 percent of actual flow over a turndown range of 6 to 1.
6. Manifold Materials: Type 316 stainless steel.
7. Unless otherwise required by application and without affecting the fan and sensor performance, nominal diameter copper and aluminum manifolds shall be the following:

    a. For Fan Inlets Smaller than 20 Inches: 0.375 inch.
    b. For Fan Inlets 20 Inches and Larger: 0.75 inch.

8. Unless otherwise required by application and without affecting the fan and sensor performance, nominal diameter stainless-steel manifolds shall be the following:

    a. For Fan Inlets Smaller than 20 Inches: 0.375 inch.
    b. For Fan Inlets 20 through 48 Inches: 0.75 inch.
    c. For Fan Inlets Larger than 48 Inches: 1.0 inch.

D. Piezometer Ring Fan Inlet Airflow Sensor:

1. Manufacturers: Subject to compliance with requirements, provide products by the following. Fan and Piezometer Ring Fan Inlet Airflow Sensor to be provided by the same manufacturer.

    a. Ventrol
    b. Twin City Fan & Blower.
    c. Or approved equal.

2. In lieu of externally mounted fan inlet airflow sensors, option to provide fans with airflow measurement integral to fan inlet cones for continuous measurement of air volume flow rate.
3. Multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.
4. Sensor points shall not protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.

5. Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.
6. Sensor shall be non-intrusive and not impact fan performance.
7. Product shall be a standard offering of the fan manufacturer and include published literature with supporting test data to validate sensor performance.

2.4 AIRFLOW SWITCHES

A. Polymer Film Sail Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Honeywell International Inc.

   b. Or approved equal.
2. Performance:

   a. Suitable for applications operating at velocities up to 400 fpm.
   b. Suitable for mounting with air direction in horizontal, vertical up or down.
   c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   d. Voltage: 24-, 120-, 240-V ac.
   e. Normally Open Full Load Current: 2 A at 120-V ac.
   f. Normally Closed Full Load Current: 1 A at 120-V ac.
   g. Normally open switch actuates at 250 fpm and opens at 75 fpm.
   h. Normally closed switch actuates at 75 fpm and closes at 250 fpm.
   i. Maximum Process Temperature: 170 deg F.
   j. Maximum Ambient Temperature: 125 deg F.

3. Construction:

   a. Polyester film sail encasing a wire frame.
   b. Sail actuates a SPDT snap switch.
   c. Enclosure Material: Zinc-plated steel.
   d. Enclosure with removable cover.
   e. NEMA 250, Type 1 enclosure.
   f. Removable spring counterbalances sail to allow mounting in either vertical (up or down) or horizontal airflow.
   g. Electrical Connections: Screw terminals.
   h. Conduit Connections: 1/2-inch trade size conduit knock outs on top and bottom.

B. Stainless-Steel Single Vane Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Dwyer Instruments, Inc.

b. Or approved equal.

2. Description:

   a. Velocities up to 2000 fpm.
   b. Suitable for mounting with air direction in horizontal.

3. Performance:

   a. Voltage: 125-, 240-, and 480-V ac.
   b. Full Load Current: 9.8 A at 125-V ac.
   c. Field-Adjustable Velocity Set Point: 400 to 1600 fpm.
   d. Maximum Process Temperature: 180 deg F.
   e. Maximum Ambient Temperature: 125 deg F.

4. Construction:

   a. Stainless-steel vane.
   b. Vane actuates a SPDT snap switch.
   c. Enclosure Material: Die-cast metal.
   d. Enclosure with removable cover.
   e. NEMA 250, Type 1 enclosure.
   f. Screw set-point adjustment.
   g. Electrical Connections: Screw terminals.
   h. Conduit Connections: 1-inch trade size conduit knock outs on top and bottom.

2.5 LIQUID FLOW METERS

A. General Requirements for Liquid Flow Meters:

1. Adjustable for changes in system operational parameters.
2. Liquid and Steam Sensors, Meters, and Transmitters: Extended range of 20 percent above Project design flow and 20 percent below Project minimum flow to signal abnormal flow conditions.
3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
4. Product certificates are required.

B. In-line Body Electromagnetic Flow Meter:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Siemens
   b. Yokogawa

2. Description:

   a. No moving parts.
   b. Suitable for flow measurement of fluids with electrical conductivity more than 5 micro-Seimens per cm.
   c. Inherent bi-directional flow measurement.

d. Flow measurement with three pipe diameters upstream and two pipe diameters downstream.
e. Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.
f. Transmitter integral to meter.

3. Performance:

a. Accuracy for Velocities between 3.3 and 33 fps: Within 0.2 percent of reading.
b. Accuracy for Velocities between 1.0 and 3.3 fps: Within 0.75 percent of reading.
c. Accuracy for Velocities Less than 1.0 fps: Within 0.0075 fps.
d. Ambient Temperature: Minus 4 to plus 140 deg F.
e. Process Temperature: Minus 4 to 212 deg F.
f. Pressure: 225 psig.

4. Analog Output Current Signal:

a. Two-wire, 4- to 20-mA dc current source.
b. Signal capable of operating into 1000-ohm load.
c. Isolated.

5. Digital Output Signal: Two, programmable, digital/pulse outputs configurable for frequency, pulse, or directional flow.
6. Operator Interface:

a. Keypad.
b. Digital Display: Multiple-line digital display of alphanumerical characters.
c. LED for normal and alarm operation.

7. Construction:

a. Body: Type 316 stainless steel.
b. Body Liner Material: PTFE, Polypropylene.
c. Flow Tube: Type 304 stainless steel.
d. Connection: 300 Class flange.
e. Electrodes: Type 316 stainless steel. Quantity determined by manufacturer based on application.
f. Electronics Enclosure:

1) Painted aluminum.
2) Removable cover.
3) NEMA 250, Type 6.

C. Insertion Electromagnetic Flow Meter:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. ONICON Incorporated.

b. Dwyer - Instruments

c. Or approved equal.

2. Description:

a. No moving parts.
b. Suitable for flow measurement of fluids with electrical conductivity between 20 to 60000 micro-Seimens per centimeter.
c. Suitable for pipe sizes NPS 3 through NPS 72.
d. Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.
e. Continuous auto-zero function.
f. Transmitter integral to meter.

3. Performance:

a. Flow Range: 0.25 to 20 fps.
b. Accuracy for Velocities between 2 and 20 fps: Within 1 percent of reading.
c. Accuracy for Velocities Less than 2 fps: Within 0.02 fps.
d. Ambient Temperature: Minus 5 to 150 deg F.
e. Process Temperature: 15 to 250 deg F.
f. Pressure: 400 psig.

4. Output Signals:

a. Field-selectable analog signals.

1) Current Signal (Isolated): 4 to 20 mA.
2) Voltage Signal (Isolated): Zero- to 10-V dc.

b. Digital Signal: Dry-contact closure signaling fault condition.
c. Frequency Signal: Zero- to 15-V peak pulse, zero to 500 Hz.
d. Scalable Pulse Output:

1) Isolated solid-state dry contact.
2) Contact Rating: 100 mA at 50-V dc.
3) Pulse Duration: 0.5, 1, 2, or 6 seconds.

5. Construction:

a. Wetted Metal Parts: Type 316 stainless steel.
b. Sensor Head: Polysulfone.
c. Process Connection: 1-inch.
d. Instrument Isolation Valve: Full port Type 316 stainless-steel ball valve for system isolation.
e. Electrodes: Type 316 stainless steel.
f. Electronics Enclosure:

1) Painted aluminum.
2) Removable cover.
3) NEMA 250, Type 4.
4) Electrical Connection: PVC-jacketed cable, 10 feet long.

5) Conduit Connection:1/2-inchtrade size.

6. Display Module:

   a. Remote from meter.
   b. House in a NEMA 250, Type 4X enclosure.
   c. Label terminal strip for all wiring connections.
   d. 120-V ac power supply with 24-V dc output to power the flow sensor.
   e. Input Signal from Meter: Zero- to 15-V pulse output.
   f. Output Signals: Additional output signals furnished with flow meter connected to display module terminal strip.
   g. Auxiliary Output Signals: Analog current output (isolated) shall be 4 to 20 mA.
   h. Auxiliary Output Signals: Analog voltage output (isolated) shall be zero to 10 V.
   i. Auxiliary Output Signals: Digital output (isolated) shall be solid-state dry contacts rated for 100 mA at 50 V.
   j. Digital Display:

      1) Flow rate.
      2) Totalized flow.
      3) At least six display digits for flow rate and eight display digits for totalization.
      4) Bi-directional units with separate digital display for flow and totalization in each direction.

   k. Local reset of flow totalization.
   l. Program and data shall be stored in nonvolatile memory in the event of power loss.
   m. For bi-directional units, provide LED display of flow direction (contacts open or closed).

7. Ultrasonic flow meter:
   a. The liquid flow-meter shall be a non-invasive transit-time meter employing the multi-pulse principle for measurement and providing an output signal linear with flow. The transducers shall be of wide beam design, capable of employing both clamp-on direct and reflect configuration. The flow metering system shall consist of an Ultrasonic Single or dual Channel flow computer, individual flow data displays for each channel, metallic transducers pipe mounting hardware and transducer cables.
   b. The flow meter shall be field-programmable with all site criteria being capable of input or change on-site by the use of plug-in hand-held terminal. All programming will be menu-driven and input in plain English.
   c. System Requirements
      1) Intrinsic Accuracy: Within 1.0 to 3.0 percent of actual flow above 1 fps.
      2) Calibrated Accuracy: Within 0.25 percent to 0.5 percent of actual flow above 1 fps.
      3) Flow Range Ability: Bidirectional including active zero sensitivity.
      4) Sensitivity: 0.001 ft/sec.
      5) Respectability: High precision: 0.15%.
   d. Flow Transmitter
      1) The flow transmitter shall be solid state design utilizing high reliability circuit elements and compound shall be micro-computer

controller. The transmitter shall be housed in a NEMA 4X enclosure suitable for wall mounting. The transmitter shall be furnished with built-in fault alarm, and self diagnostic program to accurately track the metering systems performance. The programming shall be battery backed in RAM.

2) The transmitter shall be equipped with an isolated 4-20 ma output signal, proportioned to flow, and be able to drive a restive load of up to 800ohms.

8.

2.6 LIQUID FLOW SWITCHES

A. Liquid Flow Switch (Magnetic Type):

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. W. E. Anderson; Dwyer Instruments, Inc.

   b. Or approved equal

2. Description:

   a. Field-adjustable five-vane combinations.
   b. Suitable for pipe sizes NPS 1-1/2 through NPS 20.
   c. Mounting Suitable for Application: Switch vertically mounted in horizontal pipe, or switch horizontally mounted in vertical pipe with flow up.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous-environment Class I, Groups C and D; Class II, Groups E, F, and G.

3. Performance:

   a. Flow Rate Actuation and De-actuation: Varies with vane combination.
   b. Pressure Limit: 1000 psig for brass body, 2000 psig for Type 316 stainless-steel body.
   c. Temperature Range: Minus 4 to plus 275 deg F.
   d. Electrical Rating: 10 A at 125/250-V ac.
   e. Switch Type: DPDT snap switch.

4. Wetted Parts Construction:

   a. Vanes: Type 316 stainless steel.
   b. Body: Type 316 stainless steel.
   c. Magnetic Keeper: Type 316 stainless steel.
   d. Process Connection: NPS 1-1/2.

5. Enclosure:

   a. Die-cast aluminum alloy.
   b. Threaded cover.
   c. NEMA 250, Type 4.

d. Electrical Connection: Terminal block.
e. Conduit Connection:trade size.

B. Liquid Flow Switch (Magnetic Type) for Small-Diameter Pipe:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. W. E. Anderson; Dwyer Instruments, Inc.

   b. Or approved equal.

2. Description:

   a. Suitable for pipe sizes NPS 1/2 through NPS 2.
   b. Mounting Suitable for Application: Switch vertically mounted in horizontal pipe, or switch horizontally mounted in vertical pipe with flow up.
   c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous-environment Class I, Groups A, B, C, and D; Class II, Groups E, F, and G.

3. Performance:

   a. Flow Rate Actuation and De-actuation: Not adjustable.
   b. Pressure Limit of Body: 1000 psig for brass, 2000 psig for Type 303 stainless-steel body.
   c. Pressure Limit of Tee: 250 psig for brass, 1000 psig for malleable iron, and 2000 psig for forged carbon steel and stainless steel.
   d. Temperature Range: Minus 4 to plus 220 deg F.
   e. Electrical Rating: 5 A at 125/250-V ac.
   f. Switch Type: DPDTsnap switch.

4. Wetted Parts Construction (Lower Body):

   a. Vanes: Type 301 stainless steel.
   b. Body: Type 303 stainless steel.
   c. Magnet: Ceramic.
   d. Process Connection: NPS 1/2.

5. Enclosure (Upper Body):

   a. Type 303 stainless steel.
   b. NEMA 250, Type 4.
   c. Electrical Connection: Terminal block.
   d. Conduit Connection: 3/4-inchtrade size.

6. Integral Mounting Tee Furnished with Switch:

   a. Stainless steel.
   b. Size: Match adjacent pipe.
   c. Connection: Threaded pipe.

2.7 AIRFLOW TRANSMITTERS

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Air Monitor
    b. Paragon
2. Transmitter Accuracy: ± 0.25%
3. Stability: ± 0.5% Full scale per year or less
4. Auto-zero capability by venting ports to atmosphere

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.
2. Do not begin installation without submittal approval of mounting location.

E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTRUMENT APPLICATIONS

A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

B. Duct-Mounted Airflow Sensors:

1. Thermal airflow station.

C. Outdoor airflow sensor:

1. Thermal airflow station, where shown on drawings.

D. Fan-Mounted Airflow Sensors:

1. Provide Piezometer ring fan inlet airflow sensor for all fans as shown on drawings.

E. Airflow Switches:

1. Measured Velocities 400 fpm and Less: Polymer film sail switch.
2. Measured Velocities Greater than 400 fpm: Stainless-steel single-vane switch.

F. Airflow Transmitters for Use with Pitot-Tube-Type Sensors:

1. Exhaust Air Airflow: Airflow transmitter with 0.25 percent accuracy and auto-zero feature Pressure differential indicating transmitter, switch.
2. Supply Air Airflow: Airflow transmitter with 0.25 percent accuracy and auto-zero feature Pressure differential transmitter for airflow measurement.

G. Liquid Flow Meters:

1. Hot Water, Chilled Water, and Condenser Water System: Electromagnetic flow meter.

2. Steam Condensate, Hot Water, Chilled Water, and Condenser Water System: Ultrasonic flow meter

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a 20 lbs force.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

6. Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
7. Install instruments in dry gas and non-condensable-vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inchesabove the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.6 FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Liquid and Steam Sensors:

1. Install sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.
3. Install pipe reducers for in-line sensors smaller than line size. Position reducers at distance from sensor to avoid interference and impact on accuracy.
4. Install in-line sensors with flanges or unions to provide drop-in and -out installation.

C. Liquid Flow Meters:

1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.

3. Install in-line meters with flanges or unions to provide drop-in and -out installation.
4. Insertion Meters:

    a. Install system process connections full size of meter connection, but not less than NPS 1-1/2. Provide stainless-steel bushing if required to mate to system connection.
    b. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
    c. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

D. Liquid Switches:

1. Install system process connection full size of switch connection, but not less than NPS 1-1/2. Install stainless-steel bushing if required to mate switch to system connection.
2. Install switch in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
3. In applications where top-dead-center location is not possible due to field constraints, install switch at location along top half of pipe if switch is acceptable by manufacturer for mounting orientation.

E. Transmitters:

1. Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.
2. Install liquid flow transmitters, not integral to sensors, in vicinity of sensor. Where multiple flow transmitters serving same system are located in same room, co-locate transmitters by system to provide service personnel a single and convenient location for inspection and service.

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.9 CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.11 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12months' full maintenance by manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

End of Section

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GAS INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes the Following Gas Instruments:

1. Carbon-dioxide sensors and transmitters.
2. Combination carbon-dioxide and VOC sensors and transmitters.
3. Single-point oxygen monitoring system.
4. Multipoint carbon-monoxide monitoring system.
5. VOC sensors and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.16.

1.3 DEFINITIONS

A. NDIR: Nondispersive infrared.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Installation instructions, including factor affecting performance.
3. Product description with complete technical data, performance curves, product specification sheets.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include diagrams for power, signal, and control wiring.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Samples: For each exposed product installed in finished space.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which wall-mounted instruments located in finished space are shown and coordinated with each other, showing relationship to light switches, fire alarm devices, and other installed devices using input from installers of the items involved.

B. Product Test Reports: For each product, for tests performed by a qualified testing agency.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 CARBON-DIOXIDE SENSORS AND TRANSMITTERS

A. Manufacturers: subject to compliance with requirements, provide products by the following:
1. Vaisala
2. Veris Industries
3. Or approved equal

B. Description:

1. NDIR technology or equivalent technology providing long-term stability and reliability.
2. Two-wire, 4-20 mA output signal, linearized to carbon-dioxide concentration in ppm.

C. Construction:

1. House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 1 enclosure for wall-mounted space applications and NEMA 250, Type 4 for duct-mounted applications.
2. Equip with digital display for continuous indication of carbon-dioxide concentration.

D. Performance:

1. Measurement Range: Zero to 2000 ppm.
2. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
3. Repeatability: Within 1 percent of full scale.
4. Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25 to 110 deg F.
5. Long-Term Stability: Within 5 percent of full scale after more than five years.
6. Response Time: Within 60 seconds.
7. Warm-up Time: Within five minutes.

E. Provide calibration kit, including hand held meter. Turn over to Owner at start of warranty period.

2.2 COMBINATION CARBON-DIOXIDE AND VOC SENSORS AND TRANSMITTERS

A. Manufacturers: subject to compliance with requirements, provide products by the following:
1. Vaisala
2. Veris Industries
3. Or approved equal

B. Description:

1. NDIR technology or equivalent technology that provides long-term stability and reliability.
2. Senses and responds to combined concentration of more than 30 contaminates commonly found in indoor environments.

C. Output Signal: Zero to 10-V dc.

D. Performance:

1. Carbon-Dioxide Range: Zero to 2000 ppm.
2. Carbon-Dioxide Accuracy: Within 30 ppm, plus 2 percent measured value.
3. VOC Range: Zero to 2000 ppm.
4. VOC Sensitivity Ranges: Field selectable, low, normal, high.
5. Ambient Temperature: 32 to 122 degrees F.
6. Ambient Relative Humidity: 5 to 95 percent non-condensing.

E. Provide calibration kit, including hand held meter. Turn over to Owner at start of warranty period.

F. Enclosure: White plastic.

G. Electrical Connections: Screw terminals.

H. Display: Digital, LCD.

2.3 MULTI-POINT GAS MONITORING SYSTEM

A. Manufacturers: subject to compliance with requirements, provide products by the following:
   1. MSA instrument division
   2. Kele
   3. Or approved equal

B. Description:
   1. Gas detection system will provide control functionality for up to 20 remote sensors, and provide measurement ability for multiple gases, including CO, NO2, O2, SO2, and all applicable refrigerants.
   2. Each sampling point shall monitor any variation in the carbon-monoxide concentration level.
   3. Each sampling point shall be individually piped to the monitoring system.
   4. Provide each sampling point with a 0.3-micron filter.
   5. Each sampling point shall be an alarm point.
   6. A dual-head diaphragm pump shall draw an air sample through piping system and through a microprocessor-controlled sequencer feeding an analyzer with a new sample every 15 seconds.
   7. Sample time shall be adjustable in 1 second increments from zero to 60 minutes.
   8. Span and zero calibration gas shall be automatically initiated by the microprocessor. System shall also provide manual initiation of span and zero calibration gas.
   9. Analyzer output shall be corrected by the microprocessor.
   10. Monitoring system shall have 16 sample points.
   11. System shall operate on 120-V ac, single-phase, 60-Hz power.
   12. System shall require no periodic maintenance other than periodic checking of sensor response to a known concentration of gas.
   13. System shall be designed to provide for installation, setup, and start-up from outside of unit enclosure without need to open the enclosure door.
   14. System shall be factory calibrated and ready for operation after installation.
   15. Monitor shall be internally wired to accommodate a single-point field power connection.
   16. Final adjustment; calibration, testing, and startup of the system shall be performed by a trained representative of manufacturer.

C. Analyzer:

   1. Analyzer shall operate using principle of nondispersive infrared absorption.
   2. Sampling response time shall be within 10 seconds.
   3. Zero drift and span drift shall be less than 1 percent of full scale within a 24-hour period.
   4. Repeatability shall be within 1 percent of full scale.
   5. Accuracy shall be within 1 percent of full scale.
   6. Calibration range shall be zero to 500 ppm.
   7. Digital display on analyzer face with scale shall be in ppm.
   8. Temperature shall be compensated from 30 to 120 deg F ambient temperature.

D. Performance:

   1. Range: Full scale, zero to 500 PPM CO.

2. Zero Drift: Within 1 percent per year.
3. Span Drift: Within 10 percent per year.
4. Repeatability: Within 1 percent of full scale.
5. Linearity: Within 2 percent of full scale.
6. Step Change Response Time: Within 12 seconds.

E. Enclosure:

1. NEMA 250, Type 1 or Type 12 for indoor installations. NEMA 4x for all outdoor installations.
2. Hinged and locking door, full size of face.
3. House all system components. Multiple adjoining enclosures are acceptable if joined to a common support structure.

F. Controller:

1. Password-protected access through full-function keypad.
2. Set:

    a. Real-time clock.
    b. Alarm levels.
    c. Change span-gas values.
    d. Display date of last calibration.
    e. Display minimum, maximum, and average gas values.
    f. Change address, future calibration time, and date.

3. Automatic return-to-normal-operation feature after calibration.
4. Date stamps last successful calibration.
5. Time and date stamps events.
6. Selectable lockout of output signals during calibration.
7. Logs minimum, maximum, and average gas concentrations over selected time intervals.

G. Visual Display:

1. Each sample shall send a 4-20 mA output signal proportional to the highest concentration.
2. Alphanumeric visual display of current analyzer concentration reading shall be in ppm or another industry-accepted measurement.
3. Visual indication for sample analyzing, sample high-concentration alarm, analyzer malfunction, and calibration.
4. Any number and configuration of sample points shall be capable of being bypassed.
5. Each sample point shall be capable of being manually sampled through an override feature.
6. System parameters shall be stored in nonvolatile memory.
7. Provide at least an eight-hour battery backup of current alarm status. Battery shall be rechargeable.

8. Four-digit LED or backlight LCD display visible from front face of enclosure.
9. Value displayed shall be a direct reading of gas concentration.
10. Displays system status indicators.
11. Visual Alarm Indication:

a. Three separate alarm levels: Caution, Warning, and Alarm.
b. Separate strobes for Warning and Alarm conditions. Externally mount the two strobes on top of enclosure.

12. Indication of sensor nearing end of its useful life based on the sensor output, not on the time the sensor was in service.
13. Displays average, minimum, and maximum gas concentrations of the sensor over selected time.
14. Malfunction Indication Alarm: Displays a separate unique character when an over range or under range condition exists, a sensor signal sensor is lost, or a set-point error or memory failure occurs.

H. Audible Alarm:

1. Provides an audible horn when an alarm condition occurs.
2. Horn shall be rated for 95 dB with selectable output tones.
3. Mount horn inside or on exterior of enclosure.
4. Activate horn through a horn relay. Horn relay shall be form "A" contacts and set as normally open and common.

I. Operator Interface:

1. Door Audible Alarm Acknowledge Switch:

a. Push-button switch located on front door shall silence audible alarm.
b. Switch shall reset latched alarms if normal gas conditions exist. Visual alarms shall remain on as long as alarms are exceeded.

2. Operating Modes and Parameters Selection: Selections listed shall be accomplished by the use of switches, jumpers, or remote control not involving the use of tools.

a. Display range value.
b. Latching or nonlatching mode for the alarm set points.
c. Upscale or downscale acting alarms.

J. Output Signal:

1. Relays:

a. Provide one relay for each set-point level for each of the three alarm levels.
b. Provide one relay for fault conditions.
c. Alarm and fault relays shall be form "C," DPDT. Contacts shall be rated for 5 A resistive at 250-V ac or 30-V dc.
d. Contacts shall be capable of being selected normally open or normally closed.
e. Alarm relays shall be normally de-energized. The fault relay shall be normally energized.

2. Analog Output:

a. Provide one analog output for each gas type requiring detection.
b. Signal capable of operating into a 600-ohm load.

K. Sensor:

1. Electrochemical type does not require periodic addition of reagents.

2. Dual Infrared type for refrigerant detection.

3. Accuracy: +/- 5% at PEL value.
4. Sensor shall be replaceable without the need for tools.
5. Sensors shall have a minimum useful life of five years.
6. Mount sensor externally on the side or bottom of enclosure. Where indicated on Drawings, mount sensor remote from enclosure.
7. Remote Mounting:

   a. Provide sensor in a separate enclosure. Enclosure shall be NEMA 250, Type 4X, except when sensor is installed in a hazardous location, then enclosure shall be an explosion-proof type suitable for the application.
   b. Provide sensor with cable for connecting to monitor.
   c. Provide sensor with mounting hardware suitable for application.
   d. For duct-mounted applications, the sensor installation shall provide kit for calibration of the sensor without removing sensor from duct.

L. Gas Sampling Pump:

1. Where required by application, provide a pump mounted inside the enclosure to provide a motive force to induce flow of gas sample across the sensor.
2. Signal to the sensor from the pump shall be in digital communication format to eliminate radio-frequency interference (RFI) and electromagnetic interference (EMI).
3. A flow sensor shall activate a relay when the gas sample falls below the acceptable flow rate to the sensor and shall indicate a loss of gas flow on the display.
4. Introduction of a calibration gas to the gas sensor shall be through an integral push-button valve. This push-button valve shall return to monitoring the sampled area when released.

M. Battery Backup:

1. Provide battery backup power supply to continue normal operation if normal power source is interrupted.
2. Transfer to battery backup shall be automatic and shall be indicated on the display.
3. Mount battery backup power supply inside enclosure.
4. Battery backup shall be continuously charged during normal operation.
5. Battery life shall be at least 0.5 hours with strobes flashing, alarm conditions asserted, and horn sounding.

N. Automatic Calibration System:

1. Provide automatic calibration of all gas monitors installed. Number of automatic calibration systems shall be determined by supplier based on location and quantity of oxygen monitors.
2. Automatic calibration system shall, without manual intervention, periodically perform a complete calibration of the sensor.
3. System shall exchange digital signals with sensor.
4. Automatic calibration shall be adjustable from as many as three times per day to only once every 30 days.
5. Sensor alarms shall be suppressed or disabled until the automatic calibration cycle is completed.
6. Manual calibration of the sensor shall be initiated at any time with a hand-held infrared remote control without the need to disable or turn off the automatic calibration system.
7. House the system in a separate NEMA 250, Type 4X enclosure from the oxygen monitoring system. Enclosure shall have provisions for wall mounting.
8. Digital displays shall indicate zero and when span gas is being applied to the sensor, the status, and any fault condition.
9. Provide with a separate valve condulet to monitor the condition of the calibration cylinders attached to the calibration system. Insufficient gas pressure to calibrate the sensor shall light the fault indicator.

2.4 VOC SENSORS AND TRANSMITTERS

A. Manufacturers: subject to compliance with requirements, provide products by the following:
   1. Vaisala
   2. Veris Industries
   3. Or approved equal

B. Description:

   1. VOC sensor shall use an oxidizing element that varies resistance with contaminant gases.
   2. Senses and responds to combined concentration of more than 30 contaminates commonly found in indoor environments.

C. Output Signal: Zero to 5or10-V dc with minimum load resistance of 4000 ohms.

D. Performance:

   1. Measurement Range: Zero to 100 percent.
   2. Ambient Temperature: 32 to 140 deg F.
   3. Ambient Relative Humidity: 5 to 95 percent non-condensing.

E. Enclosure: Lexan.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTRUMENT APPLICATIONS

A. Wall mounted sensors:
   1. Combination VOC and CO2 sensors

B. AHU return air measurement
   1. Separate VOC and CO2 sensors.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.

D. Fastening Hardware:

   1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
2. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
3. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

4. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inchesabove the adjacent floor, grade, or service catwalk or platform.

a. Make every effort to mount at 60 inches.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.6 CARBON-MONOXIDE MONITORING SYSTEM

A. Install sample points in monitored area to provide accurate measurement of gas concentration.

B. Install exposed sampling points with a finished appearance consistent with other materials in space. Submit proposed products to be installed for review and approval.

C. Individually install each sample point to the carbon-monoxide monitoring system.

D. Install tubing in a minimum size of NPS 3/8.

E. Use compression fittings at connections to equipment.

F. If not indicated on Drawings, locate carbon-monoxide monitoring system in a secured and serviceable location accessible to authorized personnel.

G. Support carbon-monoxide monitoring system from floor or wall. Support floor-mounted systems using a structural channel frame. Provide mounting brackets.

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.8 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures in ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

E. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

F. Switches: Calibrate switches to make or break contact at set points indicated.

G. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.10 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12months' full maintenance by skilled employees of gas system and equipment Installer. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.11 DEMONSTRATION

A. TrainOwner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate gas instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

End of Section

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Section 23 09 23.17

LEVEL INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes liquid-level switches, sensors, and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.17.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Include product description with complete technical data, performance curves, and product specification sheets.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For level instruments, to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

a. If instrument alone cannot comply with requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, filtered, and ventilated as required by instrument and application.

2.2 LEVEL SWITCHES

A. Liquid-Level Switch (Magnetic Type with Float):

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. W. E. Anderson; Dwyer Instruments, Inc.

b. Or approved equal

2. Description:

a. Mounting Suitable for Application: Horizontal or vertical switch mounting.
b. Float arm with hinge design limits vertical movement to prevent sticking.
c. Replaceable float with threaded connection.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments (Class I, Groups C and D; Class II, Groups E, F, and G).

3. Performance:

a. Level Actuation and De-Actuation: 0.75-inch deadband.
b. Body Pressure Limit: 1000 psig for brass body; 2000 psig for Type 316 stainless-steel body.
c. Float Pressure Limit: 150 psig.
d. Temperature Range: Minus 4 to 275 deg F.
e. Electrical Rating: 10 A at 125/250-V ac.
f. Switch Type: DPDTsnap switch.

4. Wetted Parts Construction:

    a. Float and Rod: Type 316 stainless steel.
    b. Body: Type 316 stainless steel.
    c. Magnetic Keeper: Type 316 stainless steel.
    d. Process Connection: NPS 1-1/2 NPT.
    e. Enclosure:

        1) Die-cast aluminum alloy.
        2) Threaded cover.
        3) NEMA 250, Type 4.
        4) Electrical Connection: Terminal block.
        5) Conduit Connection: NPS 3/4 NPT.

B. Electrode-Type Liquid-Level Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Proximity Controls; Dwyer Instruments, Inc.

    b. Or approved equal.

2. Description:

    a. Conductivity technology.
    b. Dual point level settings.
    c. No moving parts.
    d. Adjustable sensitivity.

3. Performance:

    a. Pressure Limit: 30 psig.
    b. Temperature Limit: 212 deg F.
    c. Power Supply: 120-V ac, 50 or 60 Hz.
    d. Electrical Rating: 5 A at 240-V ac.
    e. Switch Type: SPDT snap switch.

4. Probes:

    a. Electrodes: 0.125-inch diameter.
    b. Material: Type 316 stainless steel.
    c. Length: To suit application up to72 inches.
    d. Process Connection: NPS 1 NPT.
    e. Enclosure:

        1) Polypropylene.
        2) NEMA 250, Type 6.
        3) Electrical Connection: Cable and standard octal socket.

C. RF Admittance-Type Liquid-Level Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Proximity Controls; Dwyer Instruments, Inc.

    b. Or approved equal.

2. Description:

    a. Capacitive technology.
    b. No moving parts.
    c. Not affected by sticky, dusty, or clingy materials that coat or build up on probe.
    d. Immune to external radio frequency (RF) sources.
    e. Sensitivity: Eight selectable settings.
    f. Mounting: Horizontal or vertical.

3. Performance:

    a. Pressure Limit: 365 psig.
    b. Ambient Temperature Range: Minus 40 to 185 deg F.
    c. Process Temperature Range: Minus 40 to 250 deg F.
    d. Universal Power Supply: 12- to 240-V ac and dc.
    e. Electrical Rating: 8 A at 120- and 240-V ac.
    f. Switch Type: SPDT snap switch, selectable for normally open or closed operation.
    g. Response Time: 0.2 seconds.
    h. Time Delay: Adjustable, zero to 60 seconds.

4. Probes:

    a. Material: Type 316 stainless steel.
    b. Insulator Material: PVDF.
    c. Length: To suit application up to72 inches.
    d. Process Connection: NPS 1 NPT.
    e. Enclosure:

        1) NEMA 250, Type 4X.
        2) Electrical Connection: Screw terminals on removable terminal block.
        3) Conduit Connection: NPS 1/2 NPT.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a 20 lb force.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Mount switches and transmitters not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade or service catwalk, or platform.

1. Make every effort to mount at 60 inches.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 LEVEL INSTRUMENTS INSTALLATION

A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.6 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.7 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.

4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures in ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Switches: Calibrate switches to make or break contact at setpoints indicated.

E. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.8 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12months' full maintenance by manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate level instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

End of Section

Section 23 09 23.18

LEAK DETECTION INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following types of leak-detection switches:

1. Point-type, leak-detection switches.
2. Cable-type, leak-detection switches.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.18.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Operating characteristics, electrical characteristics, and furnished accessories indicating control signal, default control signal with loss of power, and electrical power requirements.
2. Product description with complete technical data and product specification sheets.
3. Installation operation and maintenance instructions including factors affecting performance.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: To include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 LEAK-DETECTION SWITCHES

A. Point-Type, Leak-Detection Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Veris Industries.
    b. W. E. Anderson; Dwyer Instruments, Inc.
    c. Or approved Equal.

2. Features: Audible and visual alarm with relay output for remote indication.
3. Alarm activated based on change in resistance.
4. Performance:

    a. Service: Water.
    b. Temperature Limits: 32 to 122 deg F.
    c. Switch Type: SPDT relay.
    d. Electric Connection: Cable attached.

5. Construction: Acrylic, ABS plastic.
6. Field Power: 24-V ac or dc.

B. Cable-Type, Leak-Detection Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. W. E. Anderson; Dwyer Instruments, Inc.

2. Control Module Features:

    a. Power and alarm LEDs.
    b. Alarm test switch.
    c. Continuous tape integrity self check.

3. Performance:

    a. Service: Water, or other conductive liquid.
    b. Switch Type: DPDT.
    c. Electric Connection: Screw terminals.
    d. Conduit Connection: 0.5 inch.

4. Construction:

a. Control Module Enclosure: Extruded aluminum.
b. Tape: Hydrophobic with connector on each end.
c. Tape Length: 15 feet. Field extendable.

5. Field Power: 24-V ac or 24- to 30-V dc.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 LEAK-DETECTION INSTRUMENT APPLICATION

A. Room leak detection: cable-type

B. Condensate pan leak detection: point-type

3.3 INSTALLATION, GENERAL

A. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to 20 lbs of force.

B. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force, or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

C. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.4 CONNECTIONS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables"for electrical power connections.

3.5 INSTALLATION

A. Mount switches not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.7 CHECKOUT PROCEDURES

A. Check installed products before continuity tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation for applicable considerations that impact performance.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. Equipment and procedures used for calibration shall meet instrument manufacturer's written recommendations.
4. Provide diagnostic and test equipment for calibration and adjustment.
5. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
6. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

7. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

C. Switches: Calibrate switches to make or break contact at set points indicated.

3.9 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12months' full maintenance by skilled employees of systems and equipment Installer. Include quarterly preventive maintenance, repair, or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper sensor operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.10 DEMONSTRATION

A. TrainOwner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

End of Section

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Section 23 09 23.19

MOISTURE INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes moisture switches, sensors, and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.19.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Product description with complete technical data, performance curves, and product specification sheets.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: To include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 MOISTURE SENSORS AND TRANSMITTERS

A. Sensors and Transmitters with Digital Display:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Vaisala.

    b. Mamac

    c. Veris Industries

    d. Or approved Equal.

2. Performance:

    a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 2.5 percent from 90 to 100 percent relative humidity when operating between 60 to 77 deg F.
    b. Relative Humidity Range: Zero to 100 percent.
    c. Factory calibrated and NIST traceable with certificate included.

3. Construction:

    a. Provide housing with integral sensor for room applications.
    b. Provide housing with remote sensor probe for ducted applications.

        1) Duct Sensor Body: 300 series stainless steel or chrome-plated aluminum, at least 2 inches long for duct-mounted applications.
        2) Provide sensor with cable for field installation in conduit.
        3) For duct-mounted applications, thread the sensor assembly for connection to a threaded mounting flange.

    c. Provide general-purpose humidity sensor unless application requires special requirements. Provide sensor with sintered stainless-steel filter for duct applications.
    d. Housing shall be ABS/PC plastic or powder-coated aluminum.
    e. Housing Classification: NEMA 250, Type 4 or 4X.
    f. Provide housing with wall-mounting plate.

4. Output Signal: 2-wire, 4- to 20-mA output signal with a drive capacity of at least 500 ohms at 24-V dc.

5. Provide unit with a digital display of relative humidity in percent.

B. Sensor and Transmitter without Display:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Vaisala.
   b. Mamac
   c. Veris Industries
   d. Or approved Equal.

2. Performance:
   a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 3 percent from 90 to 95 percent relative humidity when operating at 68 deg F.
   b. Relative Humidity Range:
      1) Duct: Zero to 100 percent.
      2) Space: Zero to 95 percent relative.
   c. Factory calibrated and NIST traceable with certificate included.

3. Construction for Space Applications:
   a. Housing with integral sensor.
   b. Housing shall be ABS plastic or powder-coated aluminum.
   c. Enclosure: NEMA 250, Type 4.
   d. Provide housing with a wall-mounting plate.

4. Construction for Duct and Equipment Applications:
   a. Housing with integral sensor.
   b. Duct Sensor Body: 300 series stainless steel.
   c. Provide sensor with sintered stainless-steel filter for duct applications.
   d. Housing shall be cast aluminum.
   e. Enclosure: NEMA 250, Type 4.

5. Output Signal: Two-wire, 4- to 20-mA output signal with drive capacity of at least 500 ohms at 24-V dc.

C. Combination Humidity and Temperature Sensor and Transmitter with Display:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Vaisala.
   b. Mamac

c. Veris Industries

d. Or approved Equal.

2. Description:

a. Factory package consisting of humidity and temperature sensor, digital display, keypad user interface, installation hardware, interconnecting sensor cabling, installation instructions, and operating manual.
b. Each transmitter shall be individually calibrated and provided with NIST traceable calibration certifications.
c. Provide a service cable for connecting to a notebook computer and Microsoft Windows compatible software.

3. Display:

a. Alphanumeric display of the following on the face of the enclosure:

1) Percent relative humidity.
2) Absolute humidity.
3) Mixing ratio.
4) Dry-bulb temperature.
5) Wet-bulb temperature.
6) Dew point temperature.
7) Enthalpy.

b. Visual display of measurement trends, and minimum and maximum values over a one-year period.

4. Electronics Enclosure:

a. Integral to sensors for wall- (room-)mounted applications and remote from temperature and humidity sensors for duct and equipment applications.
b. NEMA 250, Type 4 or 4X.
c. Labeled terminal strip for field wiring connections.

5. Programming:

a. Transmitter parameters shall be field programmable through keypad on the face of the enclosure.
b. Programmed parameters shall be stored in nonvolatile EEPROM.

6. Output Signals:

a. Three Analog Outputs: 4 to 20 mA or zero to 10-V dc for each output.

7. Temperature Sensor:

a. Temperature range matched to application, but not less than minus 40 to 140 deg F.
b. Within 0.5 deg F accuracy over the temperature range of 50 to 100 deg F and within 1 deg F over the remainder of the range.

c. Provide duct installation kit for duct applications.

8. Humidity Sensor:

a. Relative Humidity Measurement Range: Zero to 100 percent.
b. Response time in still air within 40 seconds.
c. Accuracy including non-linearity, hysteresis, and repeatability:

1) For Temperature Between 59 and 77 Deg F and Relative Humidity between Zero and 90 Percent: Within 1 percent.
2) For Temperature between 59 and 77 Deg F and Relative Humidity between 90 and 100 Percent: Within 1.7 percent.
3) For Temperature between Minus 4 and 104 Deg F: Within 1 percent plus 0.008 times relative humidity reading.
4) For Temperature between Minus 40 and 356 Deg F: Within 1.5 percent plus 0.015 times the relative humidity reading.

d. Sintered, stainless-steel filter, protecting sensor.
e. Provide duct installation kit for duct applications.

9. Power Supply:

a. Field Power: 120-V ac, 60 Hz unless otherwise required by the application.
b. Internal Power: As required by transmitter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 MOISTURE INSTRUMENT APPLICATIONS

A. Room Sensors: Combination humidity and temperature sensor and transmitter with display.

B. In duct and in-unit sensors: Sensor and transmitter without display.

C. Pipe mounted: Pipe mounted condensation detectors.

3.3 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to 15 lbs of force.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 MOISTURE INSTRUMENTS INSTALLATION

A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and Federal accessibility requirements within a range of 42 to 72 inchesabove the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.7 CHECKOUT PROCEDURES

A. Check installed products before continuity tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.

6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.9 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12months' full maintenance by manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper sensor operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.10 DEMONSTRATION

A. TrainOwner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

End of Section

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Section 23 09 23.21

MOTION INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. PIR motion sensors.
2. Ultrasonic motion sensors.
3. Dual-technology motion sensors.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.21.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Include product description with complete technical data, performance curves, and product specification sheets.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Product installation location shown in relationship to visual range and obstructions.
2. Wall- and ceiling-mounted instruments located in finished space showing relationship to other installed devices.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For motion instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 INDOOR MOTION SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bryant Electric.
2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. Lutron Electronics Co., Inc.
4. Or approved equal

B. Description: Wall- or ceiling-mounted, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn on when covered area is occupied and off when unoccupied; with a time delay for turning off, adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A load at 120- and 277-V ac. Power supply to sensor shall be 24-V dc, 150 mA, Class 2 power source as defined by NFPA 70.
4. Mounting:

a. Sensor: Suitable for mounting in any position on a standard outlet box.
b. Relay: Externally mounted through a 1/2-inch knock out in a standard electrical enclosure.
c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

5. Indicator: Digital display, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.

C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in coverage area.

1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot- high ceiling.
4. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch- high ceiling.
5. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
6. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inch- high ceiling.
7. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot- high ceiling in a corridor not wider than 14 feet.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SENSOR INSTALLATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Coordinate layout and installation of wall-mounted devices with other wall-mounted devices. Align centerline with adjacent devices. Align centerline with devices above.

C. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.3 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engagea qualified testing agency to evaluate lighting control devices and perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Motion instruments will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. Verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

3.7 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for direct-digital control systems specified in Section 230923 "Direct-Digital Control System for HVAC."

B. TrainOwner's maintenance personnel to adjust, operate, and maintain lighting control devices.

End of Section

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Section 23 09 23.22

POSITION INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes position limit switches for use in direct-digital control systems for HVAC.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.22.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include operating characteristics, electrical characteristics, and furnished accessories indicating default control signal with loss of power and electrical power requirements.
2. Include product description with complete technical data and product specification sheets.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring.

PART 2 - PRODUCTS

2.1 POSITION LIMIT SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. OMRON Corporation.

B. Description: Select type of actuating head (plunger, roller lever, or rod) to suit application.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Performance:

1. Life expectancy: Not less than 30 million mechanical operations and 750,000 electrical operations.
2. Operating Frequency: 300 mechanical operations per minute and 30 electrical operations per minute.
3. Voltage: 125-, 250-, 480-, and 600-V ac or 8-, 12-, 14-, 24-, 30-, 48-, 125-, and 250-V dc, as required by application.
4. Current Rating: As required by application.
5. Temperature Rise: 50 deg C.
6. Ambient Temperature: 14 to 175 deg F.
7. Ambient Relative Humidity: 35 to 95 percent.

D. Construction:

1. NEMA 250, Type 4X enclosure.
2. Switch Type: SPDT or DPDT, as required by application.
3. Status indicator integral to switch. Field switchable to light when contacts are actuated and operating, or contacts are free and not operating.
4. Electrical Connection: Screw or plug-in terminals.
5. Conduit Connection: NPS 1/2.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a 20 lbs force.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 POSITION INSTRUMENTS INSTALLATION

A. Mounting Location:

1. Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, and conduit to final location.
2. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.5 ADJUSTMENT, CALIBRATION, AND TESTING

A. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

B. Switches: Calibrate switches to make or break contact at set points indicated.

End of Section

Section 23 09 23.23

PRESSURE INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Liquid-pressure switches.
5. Liquid-pressure transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.23.

1.3 DEFINITIONS

A. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a control, asset management, safety, or other system using any control platform.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over

range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

B. Product Test Reports: For each product requiring test performed by a qualified testing agency.

C. Source quality-control reports.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

    a. If instrument alone cannot comply with requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument-installed location shall dictate following NEMA 250 enclosure requirements:

    a. Outdoors, Protected: Type 12.
    b. Outdoors, Unprotected: Type 4X.
    c. Indoors, Heated with Filtered Ventilation: Type 1.
    d. Indoors, Heated with Nonfiltered Ventilation: Type 12.
    e. Indoors, Heated and Air-Conditioned: Type 1.
    f. Mechanical Equipment Rooms:

        1) Chiller and Boiler Rooms: Type 12.
        2) Air-Moving Equipment Rooms: Type 12.

    g. Localized Areas Exposed to Washdown: Type 4X.
    h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 12.
    i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.
    j. Hazardous Locations: Explosion-proof rating for condition.

2.2 AIR-PRESSURE SENSORS

A. Duct Insertion Static Pressure Sensor:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Dwyer Instruments, Inc.

    b. Or approved equal.

2. Insertion length shall be at 6 inches.
3. Sensor with four radial holes of 0.04-inch diameter.
4. Brass or stainless-steel construction.
5. Sensor with threaded end support, sealing washers and nuts.
6. Connection: NPS 1/4 compression fitting.
7. Suitable for flat oval, rectangular, and round duct configurations.

B. Duct Traverse Static Pressure Sensor:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Air Monitor Corporation.

    b. Or approved equal.

2. Sensor shall traverse the duct cross section and have at least one pickup point every 6 inches along length of sensor.
3. Construct sensor of 18-gage Type T6063-T5 extruded and anodized aluminum.
4. Sensor supported with threaded rod, sealing washer, and nut at one end and a mounting plate with gasket at other end.
5. Mounting plate with threaded, NPS 3/8 compression fitting for connection to tubing.
6. Accuracy within 1 percent of actual operating static pressure.
7. Dual offset static sensor design shall provide accurate sensing of duct static pressure in the presence of turbulent and rotational airflows with a maximum 30 degree yaw and pitch.
8. Suitable for velocities of 100 to 10000 fpm and temperatures of up to 200 deg F.
9. Sensor air resistance shall be less than 0.1 times the velocity pressure at probe-operating velocity.
10. Suitable for flat oval, rectangular, and round duct configurations.

C. Outdoor Static Pressure Sensor:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Air Monitor Corporation.

2. Sensor with no moving parts.
3. Operation not affected and impaired by rain and snow.
4. Sensing plates constructed of 0.1406-inch Type 316 stainless steel.
5. Accuracy within:

    a. 1 percent of the actual outdoor atmospheric pressure when subjected to varying horizontal radial wind velocities up to 40 mph.
    b. 2 percent of the actual outdoor atmospheric pressure while subjected to varying radial wind velocities up to 40 mph with approach angles up to 30 degrees to horizontal.
    c. 3 percent of the actual outdoor atmospheric pressure while subjected to varying radial wind velocities up to 40 mph with approach angles up to 60 degrees to horizontal.
    d. Threaded,NPS 2 connection.

D. Space Static Pressure Sensor for Wall Mounting:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Air Monitor Corporation.

    b. Or approved equal.

2. Aluminum wall plate with perforated center arranged to sense space static pressure. Exposed surfaces are provided with brush finish.
3. Wall plate provided with screws and sized to fit standard single-gang electrical box.

4. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch fitting for tubing connection.
5. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.

E. Space Static Pressure Sensor for Recessed Ceiling Mounting:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Air Monitor Corporation.

2. Aluminum round plate with perforated center arranged to sense space static pressure. Exposed surfaces provided with brush finish.
3. Sensor intended for flush mount on face of ceiling with pressure chamber recessed in ceiling plenum.
4. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch fitting for concealed tubing connection.
5. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.

2.3 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch with Dual Scale Adjustable Set Point:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Cleveland Controls

    b. Or approved equal.

2. Diaphragm operated to actuate a DPDT snap switch.
3. Electrical Connections: Push-on screw terminals.
4. Enclosure Conduit Connection: Knock out or threaded connection.
5. User Interface: Dual scale set-point adjustment knob located inside removable enclosure cover.
6. Reset type: push-button manual reset.
7. High and Low Process Connections: Slip-on tubing connections.
8. Enclosure:

    a. Dry Indoor Installations: NEMA 250, Type 13.

9. Operating Data:

    a. Electrical Rating: 1.5 A at 250-V ac.
    b. Pressure Limits: 40 inches wg

c. Temperature Limits: Minus 4 to 185 deg F.
d. Operating Range: Approximately 2 times set point.

2.4 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Filter DP: Dwyer

   b. General and static sensors: Setra, Veris, Mamac

2. Performance:

   a. Range: Approximately 2 times set point.
   b. Accuracy: Within 0.5 percent of the full-scale range.
   c. Hysteresis: Within 0.10 percent of full scale.
   d. Repeatability: Within 0.05 percent of full scale.
   e. Stability: Within 1 percent of span per year.
   f. Overpressure: 10 psig.
   g. Temperature Limits: Zero to 150 deg F.
   h. Compensate Temperature Limits: 40 to 150 deg F.
   i. Thermal Effects: 0.033 percent of full scale per degree F.
   j. Shock and vibration shall not harm the transmitter.

3. Output Signals:

   a. Analog Current Signal:

      1) Two-wire, 4- to 20-mA dc current source.
      2) Signal capable of operating into 800-ohm load.

   b. Analog Voltage Signal:

      1) Three wire, zero to 10 V.
      2) Minimum Load Resistance: 1000 ohms.

4. Display: Four-digit digital display with minimum 0.4-inch- high numeric characters.
5. Operator Interface: Zero and span adjustments located behind cover.
6. Construction:

   a. Plastic casing with removable plastic cover.
   b. Threaded, NPS 1/4 swivel fittings for connection to copper tubing or NPS 3/16 barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
   c. Screw terminal block for wire connections.
   d. Vertical plane mounting.
   e. NEMA 250, Type 4.

f. Provide mounting bracket suitable for installation.

2.5 LIQUID-PRESSURE SWITCHES

A. Liquid-Pressure Differential Switch with Set-Point Indicator:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Barksdale EPD1HAA40

b. Penn P74

2. Description:

a. Brass or Type 316 stainless-steel double opposing bellows operate to actuate a SPDT snap switch.
b. Electrical Connections: Screw terminal.
c. Enclosure Conduit Connection: Knock out or threaded connection.
d. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
e. High and Low Process Connections: Threaded, NPS 1/8.
f. Enclosure:

1) Dry Indoor Installations: NEMA 250, Type 1.
2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
3) Hazardous Environments: Explosion proof.

g. Operating Data:

1) Electrical Rating: 15 A at 120- to 240-V ac.
2) Pressure Limits: At least 5 times full-scale range, but not less than system design pressure rating.
3) Temperature Limits: Minus 10 to 180 deg F.
4) Operating Range: Approximately 2 times set point.
5) Deadband: Adjustable.

2.6 LIQUID-PRESSURE TRANSMITTERS

A. Liquid Gage Pressure Transmitter with Adjustable Span:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Mamac, Setra, Veris

2. Performance:

a. Range: Minus 300 to 300 psig.

b. Span: No greater than 2 times the working differential pressure of the system to allow the highest possible resolution
c. External Span and zero adjustments
d. Minimum Span: 3 psig.
e. Reference Accuracy: 1% accuracy over the entire span
f. Repeatability: ± 0.5% at maximum span
g. Stability: Within 0.125 percent of upper range limit for 5 years.
h. Overpressure Limits: 3626 psig.
i. Process Temperature Limits: Minus 40 to 250 deg F.
j. Ambient Temperature Limits: Minus 40 to 185 deg F.
k. Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
l. Shock and vibration shall not harm the transmitter.

3. Analog Output Current Signal:

a. Two-wire, 4- to 20-mA dc current source or 0-10 VDC signal
b. Signal capable of operating into 1000-ohm load.
c. Digital signal based on HART protocol carried with current signal.
d. Dampening: Field selectable from zero to 30 seconds.

4. Operator Interface: Zero and span adjustments located behind cover.
5. Display: Digital, five-digit, two-line display with 0.4-inch- high alphanumeric characters.
6. Construction:

a. Non-wetted parts of transmitter constructed of stainless steel with a silicone fluid filled diaphragm
b. Enclosure with removable cover on each side.
c. Type: diaphragm or strain gauge
d. Arrangement: 3-valve manifold for venting, draining and calibration; pressure/temperature test ports in lieu of pressure gauges
e. Wetted parts of transmitter constructed of Type 316 stainless steel.
f. Threaded, NPS 1/2 process connection on bottom of instrument.
g. Drain/vent valve on process connection.
h. Two 1/2-inch trade size conduit connections on side of instrument enclosure.
i. Screw terminal block for wire connections.
j. NEMA 250, Type 4X.
k. Mounting Bracket: Appropriate for installation.

B. Liquid-Pressure Differential Transmitter with Adjustable Span:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. Mamac, Setra, Veris

2. Performance:

a. Range: Minus 300 to 300 psig.
b. Span: No greater than 2 times the working differential pressure of the system to allow the highest possible resolution

c. External Span and zero adjustments
d. Minimum Span: 3 psig.
e. Reference Accuracy: 1% accuracy over the entire span
f. Stability: Within 0.125 percent of upper range limit for 5 years.
g. Repeatability: ± 0.5% at maximum span
h. Overpressure Limits: 3626 psig.
i. Process Temperature Limits: Minus 40 to 250 deg F.
j. Ambient Temperature Limits: Minus 40 to 185 deg F.
k. Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
l. Shock and vibration shall not harm the transmitter.

3. Analog Output Current Signal:

a. Two-wire, 4- to 20-mA dc current source or 0-10 VDC signal
b. Signal capable of operating into 1000-ohm load.
c. Digital signal based on HART protocol carried with current signal.
d. Dampening: Field selectable from zero to 30 seconds.

4. Operator Interface: Zero and span adjustments located behind cover.
5. Display: Digital, five-digit, two-line display with 0.4-inch- high alphanumeric characters.
6. Construction:

a. Non-wetted parts of transmitter constructed of stainless steel with a silicone fluid filled diaphragm
b. Enclosure with removable cover on each side.
c. Type: diaphragm or strain gauge
d. Arrangement: 3-valve manifold for venting, draining and calibration; pressure/temperature test ports in lieu of pressure gauges
e. Wetted parts of transmitter constructed of Type 316 stainless steel.
f. Threaded, NPS 1/2 process connection on bottom of instrument.
g. Drain/vent valve on process connection.
h. Two 1/2-inch trade size conduit connections on side of instrument enclosure.
i. Screw terminal block for wire connections.
j. NEMA 250, Type 4X.
k. Mounting Bracket: Appropriate for installation.

2.7 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PRESSURE INSTRUMENT APPLICATIONS

A. Duct-Mounted Static Pressure Sensors:

1. Duct static pressure measurement: Duct insertion static pressure sensor.

B. Space Static Pressure Sensors:

1. Building static pressure measurement: Space static pressure sensor for wall mounting or Space static pressure sensor for recessed ceiling mounting.

C. Air-Pressure Differential Switches:

1. Fan high and low pressure switches: Air-pressure differential switch with dual scale adjustable set point.

D. Air-Pressure Differential Transmitters:

1. General Systems,: Air-pressure differential transmitter.

E. Liquid-Pressure Differential Switches:

1. General Systems,: Liquid-pressure differential switch with set-point indicator.

F. Liquid-Pressure Differential Transmitters:

1. General Systems,: Liquid-pressure differential transmitter with adjustable span.

3.3 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to 20 lbs of force.

C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 PRESSURE INSTRUMENT INSTALLATION

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments (except pressure gages) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
7. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

C. Duct Pressure Sensors:

1. Install sensors using manufacturer's recommended upstream and downstream distances.
2. Unless indicated on Drawings, locate sensors approximately 67 percent of distance of longest hydraulic run. Location of sensors shall be submitted and approved before installation.
3. Install mounting hardware and gaskets to make sensor installation airtight.
4. Route tubing from the sensor to transmitter.
5. Use compression fittings at terminations.
6. Install sensor in accordance with manufacturer's instructions.
7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

D. Outdoor Pressure Sensors:

1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
2. Locate wall-mounted sensor in an inconspicuous location.
3. Submit sensor location for approval before installation.

4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

E. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet; otherwise, locate switch in vicinity of system connection.

F. Liquid-Pressure Differential Switches:

1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.
3. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 3/4. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to switch.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each switch connection.
8. Do not mount switches on rotating equipment.
9. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
10. Install switches in an easily accessible location serviceable from floor.

G. Liquid-Pressure Transmitters:

1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.

2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 3/4. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to transmitter.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each transmitter connection.
8. Do not mount transmitters on equipment.
9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage and hinder accurate operation.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.7 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's recommendations.

5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of project design values.

3.9 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to one (1) visits to Project during other-than-normal occupancy hours for this purpose.

3.10 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12months' full maintenance by skilled employees of systems and equipment Installer. Include annual preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate pressure instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

End of Section

Section 23 09 23.24

SPEED INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes speed switches for direct-digital controls for HVAC.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.24.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Operating characteristics, electrical characteristics, and furnished accessories indicating operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Product description with complete technical data and product specification sheets.
3. Installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: To include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 ROTATIONAL SPEED SWITCHES

A. Rotational Speed Switch (Non-Contact Type):

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Proximity Controls; Dwyer Instruments, Inc.

    b. Or approved equal.

2. Description:

    a. Speed switch, sensor, and electronics housed in enclosure.
    b. Shaft-end-mounted disc, or split collar wrap generates an alternating magnetic field sensed by the switch.
    c. Dust, dirt, and grease proof.
    d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Group D; Class II, Groups E, F, and G; and Class III.

3. Performance:

    a. Field-Adjustable Range: 100 to 5000 rpm.
    b. Temperature Limits: Minus 40 to 140 deg F.
    c. Electrical Rating: 5 A at 115-V ac.
    d. Switch Type: SPDT.
    e. Gap Distance: Approximately 0.375 inch .

4. Operator Interface: Potentiometer.
5. Enclosure Construction:

    a. Cast aluminum.
    b. Removable cover.
    c. NEMA 250, Type 4X.
    d. Electrical Connection: Wiring, 12 inches long, furnished with switch.
    e. Conduit Connection: 1-inch trade size.

6. Disc, Guard, and Mounting Bracket Construction:

    a. Magnetic Disc: Nylon or PVC.
    b. Disc Guard: Stainless steel.
    c. Mounting Bracket: Aluminum with stainless-steel shaft.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Speed-Switch Applications:

1. General application: Speed switch, non-contact type.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support speed-switch wiring and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to 20 lbs of force.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 SPEED-SWITCH INSTALLATIONS

A. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
4. Provide diagnostic and test equipment for calibration and adjustment.
5. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
6. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

7. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
8. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

C. Switches: Calibrate switches to make or break contact at set points indicated.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

End of Section

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Section 23 09 23.27

TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Air temperature sensors.
2. Air temperature switches.
3. Air temperature RTD transmitters.
4. Liquid and steam temperature sensors.
5. Liquid temperature switches.
6. High-end, commercial-grade, liquid and steam temperature transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.27.

1.3 DEFINITIONS

A. HART (Highway Addressable Remote Transducer) Protocol: The global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bidirectional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from a technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

B. RTD: Resistance temperature detector.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Samples: Provide samples for each exposed product installed in finished space. Provide samples before the installation begins.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Product installation location shown in relationship to room, duct, pipe, and equipment.
2. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
3. Sizes and locations of wall access panels for instruments installed behind walls.
4. Sizes and locations of ceiling access panels for instruments installed in inaccessible ceilings.

B. Product Certificates: For each product requiring a certificate.

C. Product Test Reports: For each product, for tests performed by a qualified testing agency.

D. Field quality-control reports.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

    a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:

    a. Outdoors, Protected: Type 12.
    b. Outdoors, Unprotected: Type 4X.
    c. Indoors, Heated with Filtered Ventilation: Type 1.
    d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
    e. Indoors, Heated and Air Conditioned: Type 1.
    f. Mechanical Equipment Rooms:

        1) Chiller and Boiler Rooms: Type 2.
        2) Air-Moving Equipment Rooms: Type 2.

    g. Localized Areas Exposed to Washdown: Type 4X.
    h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
    i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.
    j. Hazardous Locations: Explosion-proof rating for condition.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:

1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

    a. Range: Minus 50 to 275 deg F.
    b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.

c. Repeatability: Within 0.5 deg F.
d. Self-Heating: Negligible.

4. Transmitter Requirements:

a. Transmitter required for each 100-ohm RTD.
b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.
7. Conduit Connection: 1/2-inch

C. Platinum RTD, Air Temperature Averaging Sensors:

1. 1000ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch

D. Platinum RTD Outdoor Air Temperature Sensors:

1. 1000ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch trade size.

E. Platinum RTD Space Air Temperature Sensors:

1. 1000ohms.
2. Temperature Range: Minus 50 to 212 deg F
3. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic or flush, brushed-aluminum cover.

4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.

F. Thermal Resistors (Thermistors): Common Requirements:

1. 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

    a. Range: Minus 50 to 275 deg F.
    b. Interchangeable Accuracy: At 77 deg F within 0.5 deg F.
    c. Repeatability: Within 0.5 deg F.
    d. Drift: Within 0.5 deg F over 10 years.
    e. Self-Heating: Negligible.

4. Transmitter optional, contingent on compliance with end-to-end control accuracy.

G. Thermistor, Single-Point Duct Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
4. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
5. Gasket for attachment to duct or equipment to seal penetration airtight.
6. Conduit Connection: 1/2- inch trade size

H. Thermistor Averaging Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F
2. Multiple sensors to provide average temperature across entire length of sensor.
3. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
4. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
5. Length: As required by application to cover entire cross section of air tunnel.
6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch trade size.

I. Thermistor Outdoor Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Solar Shield: Stainless steel.
4. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
5. Conduit Connection: 1/2-inch trade size.

J. Thermistor Space Air Temperature Sensors:

1. Temperature Range: Minus 50 to 212 deg F
2. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic flush, or a brushed-aluminum cover.
3. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
4. Concealed wiring connection.

K. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units(with local control):

1. Sensors with display and control to be used in all HVAC applications unless otherwise indicated.

2. 1000-ohm platinum RTD or thermistor.

3. Thermistor:

   a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
   b. Thermistor drift shall be less than plus or minus 0.5 deg F over 10 years.

4. Temperature Transmitter Requirements:

   a. Mating transmitter required with each 100-ohm RTD.
   b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.

5. Provide digital display of sensed temperature, setpoints, and CO2 (if applicable).
6. Provide sensor with local control.

   a. Local override to turn HVAC on for a limited period of 2 hours(adj.).
   b. Local adjustment of both heating and cooling temperature set point within an adjustable band.
   c. Both features shall be capable of being disabled through control system operator.

L. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units (without control):

1. 1000-ohm platinum RTD or thermistor.
   a. Temperature Range: Minus 50 to 212 deg F
   b. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic or flush, brushed-aluminum cover.
   c. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
   d. Concealed wiring connection.

2. Temperature Transmitter Requirements:

   a. Mating transmitter required with each 100-ohm RTD.

b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.

3. Provide digital display of sensed temperature, setpoints, and CO2 (if applicable).

M. Internal Black Bulb temperature Sensor:
1. Black bulb temperature sensors are used for radiant heat in indoor spaces. Black bulb temperature sensors are used to calculate comfort temperature which is specified as the average of the conductive and the radiant temperature. Units contain either a high quality thermistor or a Platinum sensing element.
2. Provide black bulb sensor in place of regular temperature sensor or thermostat where radiant panels are shown.
3. Output types:
   a. Thermistor: Resistive
   b. PT types: Resistive
4. Set point: Resistive (0-10 Ohms)
5. Mom. Switch: N/O push button
6. Accuracy:
   a. Thermistor ±0.2°C 0 to 70°C (32 to 158°F)
   b. PT types ±0.2°C @ 25°C (77°F)
7. Housing:
   a. Material: ABS (flame retardant)
8. Dimensions: (4.53 x 3.35 x 1.10”)
9. Black bulb:
   a. Material: Anodized aluminum
   b. Dimensions: 0.69 x 1.46” dia.
10. Protection: IP30
11. Ambient range 14 to 140 °F
12. Weights: 0.26lb

2.3 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Description:

   a. Two-position control.
   b. Field-adjustable set point.
   c. Manual reset.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:

   a. Operating Temperature Range: 15 to 55 deg F.
   b. Temperature Differential: 5 deg F, non-adjustable and additive.
   c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
   d. Sensing Element Maximum Temperature: 250 deg F.
   e. Voltage: 120-V ac.
   f. Current: 16 FLA.

g. Switch Type: Two SPDT snap switches operate on coldest 12-inch section along element length.

3. Construction:

a. Vapor-Filled Sensing Element: Nominal 20 feet long.
b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
c. Set-Point Adjustment: Screw.
d. Enclosure: Painted metal, NEMA 250, Type 1.
e. Electrical Connections: Screw terminals.
f. Conduit Connection: 1/2-inch trade size.

B. Thermostat and Switch for High Temperature Control in Duct Applications:
1. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
2. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Manual reset.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:

a. Temperature Range: 100 to 160 deg F.
b. Temperature Differential: 5 deg F.
c. Ambient Temperature: Zero to 260 deg F.
d. Voltage: 120-V ac.
e. Current: 16 FLA.
f. Switch Type: SPDT snap switch.

4. Construction:

a. Sensing Element: Helical bimetal.
b. Enclosure: Metal, NEMA 250, Type 1.
c. Electrical Connections: Screw terminals.
d. Conduit Connection: 1/2-inch trade size.

2.4 AIR TEMPERATURE RTD TRANSMITTERS

A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

B. House electronics in NEMA 250 enclosure.

1. Duct: Type 2.
2. Outdoor: Type 4X.
3. Space: Type 1.

C. Conduit Connection: 1/2-inch

D. Functional Characteristics:

1. Input:
   a. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.

2. Span (Adjustable):

   a. Space: 40 to 90 deg F.
   b. Supply Air Cooling and Heating: 40 to 120 deg F.
   c. Supply Air Cooling Only: 40 to 90 deg F.
   d. Supply Air Heating Only: 40 to 120 deg F.
   e. Exhaust Air: 50 to 100 deg F.
   f. Return Air: 50 to 100 deg F.
   g. Mixed Air: Minus 40 to 140 deg F.
   h. Outdoor: Minus 40 to 140 deg F.

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc .
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together.

E. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

2.5 LIQUID AND STEAM TEMPERATURE SENSORS, COMMERCIAL GRADE

A. RTD:

1. Description:

   a. Platinum with a value of 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
   b. Encase RTD in a stainless-steel sheath with a 0.25-inch OD.
   c. Sensor Length: 4, 6, or 8 inchesas required by application.
   d. Process Connection: Threaded, NPS 1/2
   e. Two-stranded copper lead wires.
   f. Powder-coated steel enclosure, NEMA 250, Type 4.
   g. Conduit Connection: 1/2-inch
   h. Performance Characteristics:

      1) Range: Minus 40 to 210 deg F.
      2) Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.

B. Thermowells:

1. Stem: stepped shank formed from solid bar stock.

2. Material: Brass (water service) or Stainless Steel (steam service) thermowell
3. Process Connection: Threaded, NPS 3/4.
4. Sensor Connection: Threaded, NPS 1/2.
5. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
6. Furnish thermowells installed in insulated pipes and equipment with an extended neck.
7. Length: 4, 6, or 8 inches as required by application.
8. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

2.6 LIQUID TEMPERATURE SWITCHES

A. Thermostat and Switch for Temperature Control in Pipe Applications:

1. Description:

   a. Two-position control.
   b. Field-adjustable set point.
   c. Manual reset.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:

   a. Operating Temperature Range: 65 to 200 deg F.
   b. Temperature Differential Deadband: 5 to 30 deg F, adjustable.
   c. Enclosure Ambient Temperature: 150 deg F.
   d. Sensing Element Pressure Rating: 200 psig.
   e. Voltage: 120-V ac.
   f. Current: 8 FLA.
   g. Switch Type: SPDT snap switch.

3. Construction:

   a. Vapor-Filled Immersion Element: Copper, nominal 3 incheslong.
   b. Temperature Scale: Fahrenheit, visible on face.
   c. Set-Point Adjustment: Screw.
   d. Enclosure: Painted metal, NEMA 250, Type 1.
   e. Electrical Connections: Screw terminals.
   f. Conduit Connection: 3/4-inch.

2.7 LIQUID AND STEAM TEMPERATURE TRANSMITTERS, COMMERCIAL GRADE

A. House electronics in NEMA 250, Type 4X enclosure.

B. Enclosure Connection: 1/2-inch trade size.

C. Functional Characteristics:

1. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
2. Default Span (Adjustable):

    a. Chilled Water: Zero to 100 deg F.
    b. Condenser Water: Zero to 120 deg F.
    c. Heating Hot Water: 32 to 212 deg F.
    d. Heat Recovery: Zero to 120 deg F.

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

D. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPERATURE INSTRUMENT APPLICATIONS.

A. Air Temperature Sensors:

1. Duct, general: Thermistor or 1000-ohm platinum RTD.
2. Outdoor, general: 1000-ohm platinum RTD.
3. Space, general: Thermistor or 1000-ohm platinum RTD.
4. Any space served by a radiant panel: black bulb temperature sensor

B. Air Temperature Transmitters:

1. Duct, general: Air temperature RTD transmitter.
2. Outdoor, general: Air temperature RTD transmitter.
3. Space, general: Air temperature RTD transmitter.

C. Liquid and Steam Temperature Sensors:

1. General: Liquid and steam temperature sensor, commercial grade.

D. Liquid and Temperature Transmitters:

1. General System: Liquid and steam temperature transmitter, commercial grade.

E. Thermostat types:
1. Unless otherwise indicated all thermostats shall be provided with an electronic display.
2. Unless otherwise indicated all non-public space thermostats (private spaces, offices, back of house areas, etc.) Shall be provided with local adjustment of both heating and cooling setpoints, a local override button, and an electronic display.

3.3 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to 20 lbs of force.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.

4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 TEMPERATURE INSTRUMENT INSTALLATIONS

A. Mounting Location:

1. Roughing In:

   a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
   b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

      1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
      2) Do not begin installation without submittal approval of mounting location.

   c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's

mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches.

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Space Temperature Sensor Installation:

1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.
6. Install sensors away from local sources of heat and heat loss, including heaters, diffusers, windows, and locations that experience solar radiation.
7. Provide an insulated back panel for any temperature sensor located on an exterior wall.

F. Outdoor Air Temperature Sensor Installation:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.

3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Single-Point Duct Temperature Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

J. Liquid Temperature Sensor Installation:

1. Assembly shall include sensor, thermowell and connection head.
2. For pipe NPS 4 and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
3. For pipe smaller than NPS 4:

    a. Install reducers to increase pipe size to NPS 4at point of thermowell installation.
    b. For pipe sizes NPS 2-1/2 and NPS 3, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
    c. Minimum insertion depth shall be 2-1/2 inches.

4. Install matching thermowell.

5. Fill thermowell with heat-transfer fluid before inserting sensor.
6. Tip of spring-loaded sensors shall contact inside of thermowell.
7. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
8. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
9. For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.7 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.8 CHECK-OUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check temperature instruments for proper location and accessibility.

C. Verify sensing element type and proper material.

D. Verify location and length.

E. Verify that wiring is correct and secure.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

C. Perform the following tests and inspections:

1. Perform according to manufacturer's written instruction.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.11 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.12 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12months' full maintenance by skilled employees of systems and equipment Installer. Include semiannual preventive maintenance, repair or replacement of worn or defective components, cleaning and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.13 DEMONSTRATION

A. TrainOwner's maintenance personnel to adjust, operate, and maintain temperature instruments.

B. Provide a complete set of instructional videos covering each product specified and installed and showing the following:

1. Software programming.
2. Calibration and test procedures.
3. Operation and maintenance requirements and procedures.
4. Troubleshooting procedures.

C. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

D. Record videos on DVD disks.

E. Owner shall have right to make additional copies of video for internal use without paying royalties.

End of Section

Section 23 09 23.30
ARCHITECTURAL LIGHTING CONTROL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Contract Drawings, conditions of Contract (including General Conditions, Addendum to the General Conditions, Special Conditions, Division 01 Specification Sections and all other Contract Documents) apply to the work of this Section.

B. Related Sections:
1. Division 01
2. 01 23 00 – Alternates
3. 01 81 13 – Sustainable Design Requirements
4. Division 23
5. 23 08 01 – Building Automation System (BAS) Commissioning
6. 23 09 23 – Direct Digital Control (DDC) for HVAC
7. Division 26
8. 26 27 26 – Wiring Devices
9. 26 51 13 – Architectural Luminaires, Sources and Components

1.2 RELATED APPENDICIES

A. Lighting Control Intent Narrative

B. Catalogue Extracts for Lighting Control System Components

1.3 SUMMARY

A. Furnish, install, test, calibrate, commission and place into operation Lighting Control Systems as specified herein, as indicated on the drawings, and as required by the job conditions. When work of this section is complete, a fully functional programmed lighting control system shall be turned over to the Owner.

B. Controls systems covered in part 2 of this section include the following:
1. Phase Dimming Control Systems
2. Analogue Dimming Control Systems
3. HVAC Integration

C. Controls devices covered in part 2 of this section include the following:
1. 0-10V Wired Dimming / Relay Room Controllers
2. Phase Dimming / Relay Room Controllers

3. Switched Power / Relay Packs, Wired
4. Preset Scene Button Station and Momentary Contact Switches
5. Occupancy Sensors
6. Digital Interior Photosensor For Dimming and Switching
7. HVAC Interface
8. Emergency Full-On System

1.4 DEFINITIONS

A. General Note on Definitions: Definitions listed here shall be used in the absences of definitions in Division 01. These definitions shall be superseded by Division 01 definitions when duplicate definitions or defined words are specified.

B. Architect: In this specification, the term "Architect" shall refer to the Architect, Interior Designer, Landscape Architect, Construction Manager, Engineer, Owner's Representative, Commissioning Agent and/or the Lighting Specifier, together or individually, as they shall decide.

C. Approved: The use of the word "Approved" shall not extend the Architect's responsibilities beyond that as defined in the General Conditions.

D. AWG (American Wire Gauge): Is a standardized wire gauge system used since 1857 predominantly in North America for the diameters of round, solid, nonferrous, electrically conducting wire. Dimensions of the wires are given ASTM standard B258.

E. DIN Rail: Is a metal rail of a standard type widely used for mounting circuit breakers and industrial equipment inside equipment racks.

F. Furnish: Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar subsequent requirements.

G. Install: Operations at Project site including unloading, temporarily storing, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.

H. Manufacturer Provided Technician: Shall be a Manufacturer’s factory certified Contractor responsible for providing integration services between the Manufacturer’s devices and other systems devices.

I. Program: Provide the initial settings of a programmable device such as a touchscreen or computer, as specified herein. Programming shall be the responsibility of the Provider, unless otherwise specified.

J. Provide: Furnish and install, complete and ready for intended use.

1.5 GENERAL REQUIREMENTS

A. Provide labor, materials, and equipment for the installation, testing, and calibration of lighting control systems as shown on the drawings and specified herein. Provide training for Owner's maintenance personnel as specified herein.

B. Refer to drawings for dimensions and details. Check and verify dimensions and details on drawings before proceeding with the Work. Report any inconsistencies or discrepancies at once to the Architect. Should it appear that the Work intended is not sufficiently detailed or explained on the drawings or in the specifications, apply to the Architect for further drawings or explanations, as may be necessary. Conform to these explanations in the Work. If any question arises about the true meaning of the drawings or specifications, refer the matter to the Architect, whose decision is final and conclusive. Under no circumstances shall any request for extra compensation be honored where the basis of claim is such a clarification by the Architect or Owner. In no case submit a bid or proceed with any part of the Work with uncertainty. The intention of this specification and the accompanying or applicable drawings is to provide completely functioning lighting control systems. The Contractor for this Work shall take full responsibility for this result.

1.6 COORDINATION

A. Contractor shall provide a coordination meeting.

1. Meeting shall coordinate the various trades, scope, order of operations, and devices connected to the Networked Lighting Control System and Building Automation System.
2. Meeting shall include: General Contractor, Electrical Contractors, Division 23 Contractors, Controls Contractor, Architect, Controls Manufacturer, and Owner's Representative.

B. Lighting control zoning shall be identified on plan. For spaces without zoning identified, provide one zone per luminaire type per space.

C. Coordinate Work with all other applicable plans and specifications, including but not limited to wiring, conduit, luminaire schedules, lighting control narratives, sequence of operations, zoning diagrams, emergency power, A/V systems, fire alarm systems, security systems, and building-wide energy management systems. Bring conflicts to the Architect's attention before proceeding with the Work. Although the location of equipment included in the Work of this Section may be shown on the Contract Drawings in a certain place, actual construction may disclose that the location for the Work does not make its position easily and quickly accessible. In such cases, call the Architect's attention to this situation before installing this Work, and comply with Architect's installation instructions.

D. Clearly indicate the work to be performed by other trades' Contractors, and the materials that are adjacent to or abutting the Work of this Section. Coordinate as required. Give ample notice of special openings required for placing equipment in the building, in order to avoid damaging other trades' work. Furnish the materials and labor for Work of this Section in ample time and in sufficient quantities so that all of the Work may be completed in proper sequence. Schedule the Work to prevent Work of this Section being damaged by other trades' work. Remove and

replace any Work so damaged at no cost to Owner. Coordinate and schedule the Work of this Section with other trades' work and with utility companies so that there shall be no delay in the proper installation and completion of any part of the job.

E. Coordinate with other Contractors regarding attachment to or openings in the materials of other trades such as pre-cast concrete, ornamental metals, or wood panels for recessed junction boxes, and other equipment.

F. Arrange the installation in proper relation to other Work and with architectural finishes so that it shall harmonize in service and appearance and so that there shall be no interference with the Work of others, including interference in location or level.

G. Where a catalog number and a narrative or pictorial description is provided, the written description shall take precedence and prevail.

H. Where Work of this Section is to be flush or concealed, install it to assure that it does not project visually or physically beyond the finished lines of floors, ceilings, or walls.

I. Verify surface conditions and furnish appropriate mounting details for each component. Submit mounting details for approval.

J. Become familiarized with all equipment listed in the luminaire schedule and this control specification and take responsibility for the successful completion of the entire lighting control installation.

1.7 QUALITY ASSURANCES

A. Comply with the General Requirements related to Quality Control, in addition to the provisions herein.

B. Acceptable Manufacturers are listed herein. See Paragraph 2.1, below, for more information.

C. Statement of Application:

1. By commencing the Work of this Section, the Contractor assumes overall responsibility, as a part of the warranty of the Work, to assure that assemblies, components and parts shown or required within the Work of this Section, comply with the Contract Documents.
2. Warranty: In addition to any warranties required by the General Requirements, the Contractor for the Work of this Section shall:
    a. For a period of one year after Owner's initial acceptance and establishment of the beginning date of the warranty period, and at no additional cost, promptly provide and install replacements for any lighting control system components that in the opinion of the Owner are defective in materials or workmanship under normal operating conditions; or repair installed equipment at the job site to Owner's satisfaction. Contractor also warrants replacement components to be free of defects in

workmanship and materials for a period of one year following replacement and shall replace any defective replacements.

b. Contractor shall not be held responsible for acts of vandalism or for abnormal or accidental abuse of the lighting control systems occurring after the beginning of the warranty period, nor shall the Contractor be held responsible for deleterious effects caused by maintenance procedures performed without the concurrence of the Contractor.

D. Equipment Compatibility:

1. All components of a particular type of lighting control system shall be fabricated or supplied and warranted by a single (primary) Manufacturer, unless specifically noted otherwise in the Contract Documents.

E. Regulatory Agencies:

1. Provide lighting control systems wired and installed in compliance with the current edition of all applicable city, state, and national codes. Additionally, each lighting control system shall be listed by UL in its entirety and each panel shall be approved by an NRTL facility such as UL, ETL, or CSA/US.

2. In the case of international projects, the Contractor shall provide a copy of CE (European Conformity) certification and any other specified test results as required by the local inspection agency in writing on a per luminaire basis during the submittal review process.

F. Recognized Standards:

a. In addition to standards that may be referenced in Division 01, all items of equipment and individual components shall comply with the applicable standards of the following organizations:
b. UL - Underwriters Laboratories
c. NRTL - Nationally Recognized Testing Laboratory
d. NEC - National Electric Code
e. ANSI - American National Standards Institute
f. ASTM - American Society of Testing and Materials
g. NEMA - National Electrical Manufacturers Association
h. IEC - International Electrotechnical Commission
i. USITT - United States Institute for Theatre Technology
j. ESTA - Entertainment Services and Technology Association

1.8 SUBSTITUTIONS:

A. Furnish equipment exactly as specified unless substitutions are mutually agreed upon by Architect and Contractor.

B. The Manufacturers' products listed below form the basis of design. Any proposals for substitutions must be submitted at least three weeks prior to the end of the bid period. The substituted product must meet every criterion of the performance specifications and the characteristics of the specified Manufacturer and be compatible with the specified luminaires and integral control devices. Further, the

submittal package for substitutions shall be comprehensive and convincing. Any differences in achieving the intended results, between the proposed Manufacturer and the named Manufacturer's products shall be clearly delineated and the consequences thoroughly explained. Substitution submittal shall include detailed wiring diagrams specifically tailored for this project.

C. Manufacturer's lead time shall not be a justification for substitutions. The schedule specified herein must be followed to ensure that specified product is ordered in a timely manner.

D. Written documentation shall clearly show that the proposed Manufacturer meets each line item in the Specification, Lighting Control Intent Narrative and reference electrical and mechanical drawings, and if not, note any exceptions. Where proposed substitutions alter the functional or visual design or change the space requirements or mounting details indicated herein or on the drawings, such changes shall be detailed in the proposal and costs indicated for revised design and construction for trades involved. Cost data shall be provided as called for in the General Requirements. Submittal shall include names and addresses of similar projects on which the proposed product was used, including names and phone numbers of Specifiers and Owners of each project, and dates of installation.

E. Substitutions shall not be considered that may compromise the performance criteria for Building Codes, Energy Codes, LEED, or other project requirements. If impact is not clear, submit verification, calculations, and Manufacturer's data demonstrating equivalent performance.

1.9 ALTERNATE

A. Provide bidding for alternate system design as specified on sheet M9.10.

1.10 BIDDING

A. Follow the bidding procedures as described in Division 01 of this specification.

1.11 SUBMITTALS

A. General:

1. Shop drawings, samples, test data and certificates shall be submitted for approval in accordance with the requirements of the Contract Documents and General Requirements. Lighting control system components shall not be shipped, stored, or installed into the Work unless prior approval has been received, based upon the submittal of shop drawings, samples, catalogue cuts, test data, certificates, or other material submitted for approval.
2. Submittals shall include Manufacturer's default calibration settings for each device and application.
3. Submit samples of all finishes and all visible faceplates, outlets, and trim for components installed in finished spaces, when requested by Architect.

4. After the final inspection, provide a complete set of as-built control drawings as part of the Operating and Maintenance Manual. See Part 3, below, for more information.

B. Submittal Schedule (Note: All days, weeks, or months listed are "calendar" days, weeks, or months and not “working” days, weeks, or months):

1. Submit shop drawings not less than twenty-six (26) weeks before lighting control system components are required on the site. Clearly indicate Manufacturer’s lead times for fabrication of all components.
2. Within twenty (20) days after receipt of shop drawings marked "No Exceptions Taken" or "Make Corrections Noted", Contractor shall release the lighting control systems for fabrication and forward to the Architect and Owner verification that the lighting control systems have been released for fabrication and a guaranteed shipment date for each component.
3. All samples shall be received by the Architect within fourteen (14) days after Contractor's receipt of shop drawings marked "No Exceptions Taken" or "Make Corrections Noted".
4. Within fourteen (14) days after Contractor's receipt of shop drawings marked "Revise and Resubmit" or "Rejected", Contractor shall resubmit revised shop drawings to the Architect, in accordance with the General Requirements regarding re-submissions.
5. Contractor shall notify the Architect of any potential scheduling problems, or of any submittals that have not been returned to the Contractor which are required to maintain the installation schedule. Such notification shall be in a timely manner and well in advance of the time such delay might affect the fabrication schedule or appropriate delivery of lighting control system components.
6. Request for Final Layout: At the same time that shop drawings are submitted, request verification of final layouts and control zones for all luminaires. Submit templates for labeling of all controls. Layout adjustments shall be considered no-cost clarification so long as the quantity or value of control parts does not increase. Furnish blank control station faceplates until labels are available. Custom engraved or labeled faceplates shall be ordered from the Manufacturer so that they arrive prior to the final release of the space and subsequent beginning of the warranty period. Blank faceplates shall be replaced with custom labeled faceplates at no additional cost to the project.

C. Shop Drawings:

1. Luminaire Manufacturer and/or lighting controls Manufacturer shall produce a test report for each fixture type and the controls system specified. If no report exists for a fixture type and its control system, then it is the responsibility of the luminaire Manufacturer and the controls Manufacturer to test components for compatibility before submittals will be accepted. The report shall include the following:
   a. Exact luminaire part number used.
   b. Exact driver part number used.
   c. Exact controller part number used.

d. Settings used during mockup, if any available.
e. Percentage of total output at the highest dimmed state.
f. Percentage of total output at the lowest dimmed state when dimmed down from highest state over 60 seconds.
g. Percentage of total output at the lowest dimmed state when dimmed up from off state.
h. If flickering is present, at which percentage of total output flickering begins.

2. Submit a one-line diagram showing all components of the lighting control system. Show all panels, dimmers, controls, input and output jacks, and the interconnect wiring between all components.
3. Submit a dimming load schedule that clearly lists the actual loads per circuit, which circuits are wired for emergency power, and the corresponding circuit numbers (per the electrical drawings). Each load schedule shall be arranged (by zone and circuit number) to match as closely as possible the panels / schedules shown in these specifications or on the drawings.
4. For Guaranteed Maximum Pricing (G.M.P.) Submit a detailed breakdown of bid by material cost, labor, and wiring and quantities for each luminaire, when requested.
5. Submit standard cut sheets or catalogue data for all lighting control system components which includes performance data, and which clearly indicates compliance with the Specifications.
6. Each control Manufacturer shall substantiate conformance to the Specifications by submitting a written document included with the shop drawings, indicating that the equipment submitted meets each line item in the Specification, Lighting Control Intent Narrative and reference electrical and mechanical drawings, and if not, note any exceptions. Indicate how the proposed product exceptions still meet the intended performance described, specified or provided by the “basis of design.” Submit all relevant UL file cards or test reports which cover the equipment submitted, to demonstrate compliance with the Specifications.
7. The Owner and Architect reserve the right to change any of the zone designations for the lighting control circuits up until the date the final submittal responses are due back to the Contractor. These shall be considered “clarifications” as long as the overall quantity, wattage and number of zones and system elements remain the same. Zones designated as spares may be utilized at this time without incurring any additional costs to the project.

1.12 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Lighting control system components shall be delivered to the job site factory-assembled and wired to the greatest extent practical, in strict accordance with the approved shop drawings, samples, certificates, and catalogue cuts, and shall be handled in a careful manner to avoid damage.

B. Exposed finishes shall be protected during manufacture, transport, storage, and handling. Delivered materials shall be identical to approved samples. Materials that become damaged shall be repaired and/or replaced as directed at no added cost to Project.

C. Components shall be stored under cover, above the ground, in clean, dry areas, and shall be tagged and/or marked as to type and location. Wet or damp wrapping shall be removed, disposed of and replaced with dry wrapping material to prevent damage.

1.13 WARRANTIES

A. Warranties shall be in addition to, and not a limitation of other rights the Owner may have under the Contract Documents.

1. All systems, including all parts and labor, shall be under full warranty for a period of not less than five (5) years from the date of written final acceptance. In the event that any of the equipment should fail to perform or meet design characteristics as specified, it shall be replaced with equipment that will meet requirements without additional cost. After occupancy, any necessary work performed shall be done at the convenience of the Owner’s operational schedule, including overtime, if required

B. Two signed copies of the warranty are required as a condition for final approval of the work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Provide materials, equipment, appurtenances, and workmanship for the Work of this Section conforming to the highest commercial standards, as specified and indicated on the drawings.

B. Contractor shall be responsible for providing luminaires, drivers, controls, and control components that are compatible with each other. Incompatibilities in a control system shall be resolved by the Contractor at no added cost to the Project.

C. Named Manufacturers, when listed below, are representative of an adequate level of quality and reputation, and can submit a product, provided they are capable of satisfying the provisions of the specifications in every respect. This does not mean that any standard product provided by that Manufacturer is automatically qualified. Manufacturers not on this list may be proposed during the substitution period if they can provide substantiation that their product meets every particular of the relevant specification, and are of comparable quality, experience and reputation. See the paragraph titled "Substitutions", above. The Architect may reject any product without detailed explanation.

D. Dimming and relay panels, dimmers, relays, and lighting control stations [OR] The main control system networked equipment shall be fabricated by a single primary Manufacturer. System components not fabricated by the primary Manufacturer shall be included in the primary Manufacturer's shop drawings, and explicitly endorsed and warranted by the primary Manufacturer. The primary Manufacturer shall assume overall responsibility for compatibility of their system with any other Manufacturer's components. The primary Manufacturer shall have at least ten (10) years' experience manufacturing lighting control systems, and shall offer telephone support 24 hours per day, 365 days per year. Manufacturer shall ship repair and replacement parts overnight and shall have service engineers available within 48 hours of any service request.

E. Any remote control devices required to calibrate and modify the settings of the lighting controls specified in these contract documents shall be included as part of the project. Provide Owner with one unit of each unique type of calibration device.

F. Lighting Control Devices Basis of Design Primary Manufacturer:

1. Wattstopper
   Exposure 2 Lighting
   850 Summer St.
   Boston, MA 02127
   617.269.9900

2.2 LABELING

A. All faceplates and local controls shall be permanently labeled (engraved, etched or silk screened), as per direction of Architect. Exceptions: single gang, up to 2-zone controls in enclosed spaces. Provide temporary faceplates for occupancy until labels are finalized. Provide common, labeled faceplates for any multi-gang controls.

B. Any faceplates not in view of the load being controlled shall have a pilot light to indicate load is on or off.

C. Remote equipment, like controllers or remote drivers in ceiling shall be labeled.

D. Control equipment in electrical closets shall be clearly labeled to match zones as included on contract documents.

E. Control interfaces shall be labelled with the receiving and sending signal, control zone, and shall be shown on record drawings.

2.3 LIGHTING CONTROLS SYSTEMS

A. General

1. The lighting controls systems detailed below shall be adhered to in the strictest standards. Any alterations or substitutions will not be accepted unless prior written approval is given by the Architect. Any damages or faulty controls due to unapproved alterations or substitutions shall be repaired or replaced at the expense of the Contractor.
2. No interfaces shall be used, except where specified or prior written approval by the Architect is given.
3. Controls Contractor shall provide and install the Lighting Controls System as specified herein and on the electrical and mechanical drawings. System shall be capable of controlling the quantities of zones, scenes, and features specified herein.

B. Phase Dimming Control Systems

1. The phase dimming control system shall be a system that provides a reverse or forward phase dimmed line voltage to a compatible luminaire for flicker free dimming. The system shall only use the two line voltage conductors feeding the luminaire and shall only dim the fixture using the AC voltage powering the luminaire.
2. Lighting controls Manufacturer and luminaire Manufacturer shall refund the cost of or replace any luminaires or components damaged on site due to incompatibilities if a mockup has been completed.

C. Analogue Dimming Control Systems

1. The analogue dimming control system shall be a system connected with non-proprietary components or interfaces using an IEC and NEC approved 0-10V protocol in a daisy chain topology.

2. Contractor shall verify compatibility of luminaire and controller prior to ordering. If compatibility is unknown, lighting controls Manufacturer and luminaire Manufacturer shall provide a small mockup to test compatibility, at no added cost to the project.

D. Digital-Network Lighting Control System

1. Integrates sensors and other low voltage controls, devices, and subsystems through multiple control interfaces with compatible control signal. Enables the addition of relays, I/O ports, serial COM ports, shade controllers, and AV integration.
2. The system shall use non-proprietary wiring and connectors, where hardwire connections are required.
3. Enables light management software to control and monitor compatible dimming drivers, controls interfaces, power panels, and power modules.
4. Integrates control station devices, power panels, preset lighting controls, and external inputs into a single customizable lighting control system.
5. Computers Provided by Lighting Control System Manufacturer: Computer software to be preinstalled and tested prior to shipping.
6. Contractor shall provide additional hardware for a complete installation of the system and verify compatibility of other lighting control systems and devices specified herein.

E. HVAC Integration

1. Provide HVAC Integration as specified herein.
2. Provide connection to HVAC equipment and integrate lighting controls with mechanical system. Coordinate with Electrical Engineer, Mechanical Engineer, Electrical Contractor, and Controls Contractor.

2.4 0-10V WIRED DIMMING / RELAY ROOM CONTROLLERS

A. General

1. Basis of design manufacturer shall be Wattstopper LMRC-211
2. Provide 0-10V dimming control.
3. Shall be compatible with all devices occupying space and provide low voltage power to connected devices.
4. UL924 rated, coordinate with electrical engineer drawings.

B. Electrical

1. Per zone, shall incorporate (1) Class 1 relay, (1) 0-10 VDC dimming output.
2. Shall contribute low voltage power to the rest of the system.
3. Shall accept 120V or 277 VAC, be plenum rated, and provide Class 2 power to the system.
4. Shall be compatible with additional load controlling devices, such as powerpacks.

5. Shall provide up to 16 Amps switching of each lighting load zone as well as 0-10 VDC dimming.
6. Specific Power/Secondary Packs shall be available that are UL924 listed for switching of Emergency Power circuits.
7. Shall be capable of HVAC control, where necessary. Refer to HVAC Integration specified herein.

C. Physical

1. Shall be plenum rated.
2. Shall use non-proprietary connectors and wiring to connect and control luminaires.

D. Thermal

1. Rated for operation in ambient air temperature ranging from 32°F to 104°F.

E. Calibration Settings

1. Every parameter shall be available and configurable remotely from the software.

2.5 PHASE DIMMING / RELAY ROOM CONTROLLERS

A. General

1. Basis of design manufacturer shall be Wattstopper LMRC-221
2. Provide flicker free universal phase dimming control.
3. Shall be compatible with all devices occupying space and provide low voltage power to connected devices.
4. UL924 rated, coordinate with electrical engineer drawings.

B. Electrical

1. Per zone, shall incorporate (1) Class 1 relay and LED compatible universal phase dimming output.
2. Shall contribute low voltage power to the rest of the system.
3. Shall accept 120V or 277 VAC, be plenum rated, and provide Class 2 power to the system.
4. Shall be compatible with additional load controlling devices, such as powerpacks.
5. Shall provide up to 16 Amps switching of each lighting load zone.
6. Specific Power/Secondary Packs shall be available that are UL924 listed for switching of Emergency Power circuits.
7. Shall be capable of HVAC control, where necessary. Refer to HVAC Integration specified herein.

C. Physical

1. Shall be plenum rated.
2. Shall use non-proprietary connectors and wiring to connect and control luminaires.

D. Thermal

1. Rated for operation in ambient air temperature ranging from 32°F to 104°F.

E. Calibration Settings

1. Every parameter shall be available and configurable remotely from the software.

2.6 SWITCHED POWER / RELAY PACKS, WIRED

A. General

1. Basis of design Manufacturer shall be Wattstopper LMRC-101
2. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button.

B. Electrical

1. Power Packs shall incorporate one Class 1 relay and contribute low voltage power to the rest of the system. Secondary Packs shall incorporate the relay and 0-10 VDC or line voltage dimming output, but shall not be required to contribute system power. Power Supplies shall provide system power only, but are not required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.
2. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system.
3. Power Packs (Secondary) shall be available that provide up to 16 Amp switching of all lighting load types.
4. Power Packs shall be available that provide up to 5 Amps switching of all lighting load types LED drivers.
5. Specific Power/Secondary Packs shall be available that are UL924 listed for switching of Emergency Power circuits.
6. Devices shall have two RJ-45 ports.
7. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.

C. Physical

1. Power Pack shall securely mount to junction location through a threaded 1/2 inch chase nipple or be capable of being secured within a luminaire ballast channel. Plastic clips into unction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.

2. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.

D. Thermal

1. Rated for operation in ambient air temperature ranging from 14°F to 104°F.
2. Static Immunity: 15kV
3. Conducted lightning and line transient immunity: 6kV

E. Calibration Settings

1. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button.

2.7 PRESET STATION AND MOMENTARY CONTACT SWITCHES

A. General

1. Basis of design Manufacturer shall be Wattstopper LMSW-100 series
2. A preset station is defined as a device used to toggle luminaires on or off in addition to dimming by preset. Presets may connect to a master controller which can adjust preset intensities. The station, any power packs, or master controllers, as specified herein, shall be of the same single Manufacturer. If specified with relay panels, shall be of a different Manufacturer if compatibility can be proven.
3. Presets specified herein shall provide momentary contacts and power pack for compatible luminaires and compatible controllers.
4. Shall be capable of providing single momentary contacts equal to the number of control zones or sequences within the space it occupies unless specified elsewhere.
5. Shall be capable of controlling multiple loads or single scene.
6. Shall be capable of multi-way functionality to work in tandem with other switches.
7. Shall be capable of controlling the number of zones specified herein.
8. Shall be capable of local and remote programming.
9. Shall be capable of being pre-programmed with default scenes including on and off.

B. Electrical

1. Class 2 wiring with 15-24V DC operating voltage.
2. LED indicator light per switch.
3. FCC compliant for part 15.
4. Shall use CAT5 or better wire with 8P8C connectors or topology free non-proprietary wiring and connections for direct and pass thru connections.

C. Physical

1. Provide single faceplate and labelling for single or multi gang boxes.
2. Meets or exceeds RoHS restrictions
3. Hidden configuration button to reprogram contact functionality.
4. Shall have no visible fasteners, screws, or hardware when properly installed.

D. Thermal

1. Rated for operation in ambient air temperatures ranging from 32°F to 122°F.
2. Rated for operation in relative humidity of up to 90%.

2.8 OCCUPANCY SENSORS

A. General

1. Basis of design Manufacturer shall be Wattstopper DT-300
2. Sensors shall detect motion through one of three methods:
   a. Ultrasonic: By emitting high frequency audio signals and listening for a Doppler shift in the return signal. Sensor shall not emit any audible sound and shall be designed in such a way that it does not interfere with properly operating hearing aids or other devices.
   b. Passive Infrared: By passively sensing changes in the infrared radiation received by the sensor from various zones in the room. Sensors shall be sensitive to small hand motions and sensitivity shall be adjustable.
   c. Dual technology sensors may be used if they prevent both false ONs (in occupancy sensing mode) and false OFFs (in vacancy sensing mode). They incorporate Doppler shift ultrasonic and passive infrared motion detection technologies. Products that react to noise or ambient sound shall not be considered.
3. Coverage Patterns shall be tested and verified using the NEMA WD 7 guidelines.
4. Manufacturer’s gross rated area of coverage shall be de-rated as recommended by Manufacturer based on mounting height of sensor, furniture and partition locations, and finish of interior surfaces. Sensors shall be able to detect typical motion (e.g., walking in corridors; writing and computer use in offices) throughout the accessible portions of spaces lighted by controlled luminaries.
5. Contractor to provide Manufacturer with contract documents showing all proposed sensor locations and types, as well as furniture locations, for all areas where occupancy sensors will be installed. Contractor to verify sensor quantity, locations, and aiming with Manufacturer prior to ordering and installation of any sensors.
6. Sensors shall be located to avoid false positives from motion outside of the area lighted by the controlled luminaires.
7. Sensors shall be mounted flat against the ceiling, in locations shown on the Electrical Drawings, Manufacturer’s field survey drawings or as required by

field conditions. Do not install sensors in locations where air blows across them, or where their view of the area they are controlling is obstructed by dropped beams, soffits, or other irregular ceiling conditions. Maintain a minimum 6' separation between sensors and HVAC supply diffusers or as recommended by sensor Manufacturer.

8. When sensors located in adjacent lighting control zones have overlapping coverage areas, provide sensors which are designed in such a way that they do not interfere with one another.
9. All sensors shall provide an LED indicator light as a visual means of indication at all times to verify that motion is being detected during both testing and normal operation. Sensor shall be clearly visible throughout coverage range and flash each time motion is detected.
10. Where specified, sensor shall have an internal additional isolated relay with Normally Open, Normally Closed, and Common outputs for use with HVAC control, Data Logging and other control options. Sensors utilizing separate components or specially modified units to achieve this function are not acceptable.
11. Sensor shall be able to provide the following information to building control system such as BACnet.
    a. Detection state
    b. Sensor time delay
    c. Sensor sensitivity, PIR and Ultrasonic
12. Sensors shall have a concealed override switch or other provision that allows maintenance personnel to easily bypass the sensor in case of malfunction. Bypassing the sensor shall result in a continuous "on" signal being sent to connected power pack(s), so that the lights remain on.

B. Electrical

1. Sensors shall be Class 2 devices. Provide 6' diameter slack in the cable connecting each sensor with its power pack to allow for sensor relocation.
2. Power failure memory: Controls shall incorporate non-volatile memory. Should power be interrupted and subsequently restored, settings and learned parameters saved in protected memory shall not be lost.
3. Designed and tested to withstand discharges without impairment of performance when subjected to discharges of 15,000 volts per IEC 801-2.

C. Physical

1. All visible components shall be finished in NEMA standard colors.
2. Architect shall be free to choose between all standard colors offered by Manufacturer for all visible components during submittal process.
3. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up
4. When requested, be able to provide customizable mask to block off unwanted viewing areas for all sensors using infrared technology. Fresnel lenses of passive infrared sensors shall be "masked" as required to prevent the sensors

from detecting motion outside the areas they are controlling. Manufacturer shall provide masking tape which matches the color of the sensor.

5. All physical adjustment mechanisms shall be concealed from view but shall be readily accessible to maintenance personnel using common hand tools.

D. Thermal

1. Rated for operation in ambient air temperature ranging from 50°F to 104°F.

E. Calibration Settings

1. Sensors shall be factory calibrated and verified by the Contractor to the desired settings. Verify such setting criteria during the submittal phase.
2. Ultrasonic ceiling sensors shall be set to “medium sensitivity”, and 20 minute time delay.

2.9 DIGITAL INTERIOR PHOTOSENSOR FOR DIMMING AND SWITCHING

A. General

1. Basis of design Manufacturer shall be Wattstopper LMLS-500
2. Photosensor shall provide relay and dimming control for compatible luminaires and compatible controllers.
3. Output response level range capable of sensing 5-2,000 FC within visible spectrum.
4. Required adjustable sensor setpoint range of 20-60 FC but a wider range shall also be acceptable.
5. Shall be compatible with remote switches for manual override.
6. A photosensor is defined as a photodiode (a device that senses light levels), a power pack (if low-voltage), and a control module. The control module can be either remote or integral. The photodiode, power pack, and controller shall be from the same single Manufacturer.
7. Where devices are specified as closed loop dimming, dual-loop shall be an acceptable equal so long as the device meets all other specifications.
8. Dual function occupancy and photo sensors may be submitted as an equal so long as the device is located and used in the daylight sensing mode only, and meets all other specifications and the number of devices on the project does not increase therefore.
9. The Manufacturer shall verify or relocate photodiode locations shown on contract drawings. Final locations may be adjusted in the field by Manufacturer and/or Lighting Consultant. An additional 6’-0” of electrical lead shall be provided during installation for the photodiode component, to allow field adjustments.
10. Adjustable time of 10 seconds or greater for linear output dimming from minimum to maximum and maximum to minimum.

11. To ensure quality and reliability, photosensor shall be manufactured by an ISO9002 certified manufacturing facility and shall have a defect rate of less than 1/3 of 1%.
12. The following shall only be used for photosensors with a control module
    a. The control module shall be capable of controlling up to three zones utilizing a single photodiode. The control module shall provide separately adjustable settings for each control zone.
    b. For daylight dimming, these settings shall limit the voltage output of the dimming driver when the control module is operating in automatic mode.
    c. The control module shall be suitable for panel mounting on a DIN rail. All necessary adjustments and calibrations shall be made to the control module only; none shall be necessary at the photodiode location.
    d. The control module shall be capable of responding to a control interlock signal from an occupancy sensor, time clock, relay, or energy management system.
13. For open loop dimming the following shall only be used for photosensors used with a pre-set station
    a. The photosensors shall be field programmable, so that at least the following settings may be input and (lockable or) changed at any time:
        1) It shall be possible to set at least three different thresholds at which the lighting changes from one scene to the next. For example, when daylight levels drop below 400 fc, the lighting changes from scene 1 to scene 2; when daylight levels subsequently drop below 100 fc, the lighting changes from scene 2 to scene 3; and when daylight levels subsequently drop below 20 fc, the lighting changes from scene 3 to scene 4.
        2) Each threshold shall incorporate a dead band in which the presets will not be switched. This dead band shall be different for each threshold if desired. The dead band shall be field programmable, including a range of at least 5 footcandles to 100. In the example above, a 50 fc dead band would mean that the lighting would not switch from scene 2 to scene 1 until the daylight levels rose above 450 fc.

B. Electrical
1. Shall use non-proprietary class 2 wiring for communication connections listed below:
    a. Category 5e or better for non-DMX RJ45 connections.
2. Shall have non-volatile memory for all settings.

C. Physical
1. Minimum of 60° field of view at an asymmetric viewing angle.
2. Capable of mounting to hard and dropped ceilings with minimal mounting hardware and shall conceal control wiring behind ceiling if recess mounted.
3. Shall have LED status indicators.

D. Thermal
   1. Rated for operation in ambient air temperatures ranging from 32°F to 120°F.

E. Calibration Settings
   1. Shall be calibrated wirelessly with remote provided by Manufacturer. If calibration requires the purchase of 3rd party equipment such as an iPhone, Contractor shall provide 3rd party equipment with the latest version of the application and the correct version of the operating system. Contractor is responsible for purchasing and coordinating delivery of any 3rd party equipment at the direction of Manufacturer. Manufacturer shall provide, with the specification documents, a bill of materials for the exact make, model, and operating software required to run the latest version of the commissioning application. Commissioning hardware shall remain on location and be passed off to Owner after substantial completion.

2.10 HVAC INTERFACE

A. General
   1. Basis of design Manufacturer shall be Wattstopper LMBC-300
   2. Provide connectivity between DLM local network and BACnet network.
   3. MS/TP BACnet automatic configuration.
   4. Compatible connection with all room controls, relay packs, sensors, and switches specified herein.

B. Electrical
   1. Shall use non-proprietary class 2 wiring for communication connections listed below:
      a. Category 5e or better for non-DMX RJ45 connections.
      b. RS485 wire rated for BACnet MS/TP
   2. Operating voltage: 24VDC
   3. Shall have non-volatile memory for all settings.

C. Physical
   1. Plenum rated.
   2. Removable terminal block.
   3. Shall have LED status indicators.

D. Thermal
   1. Rated for operation in ambient air temperatures ranging from 32°F to 158°F.

E. Calibration Settings
   1. Shall be calibrated via DLM network or BACnet MS/TP network.

2.11 EMERGENCY FULL-ON SYSTEM

A. Emergency full-on lighting controls shall be provided as specified by the Electrical Engineering drawings and specifications under Division 26.

PART 3 - EXECUTION

3.1 GENERAL

A. Install all lighting controls and components in accordance with Manufacturer's installation instructions and with all necessary equipment, materials, parts, attachments, devices, hardware, supports, channels, enclosures and brackets necessary to make a safe, complete, and fully operative installation.

B. Do not install cover plates or other finished components until completion of wet work, plastering, painting, and general clean-up.

C. Mount lighting controls and wall jacks at heights and locations indicated in the Contract Drawings or as directed by Architect.

D. Ground non-current-carrying parts of all electrical equipment in accordance with UL and NEC provisions.

E. Run separate neutrals for all zones and branch load circuits.

F. No power is to be applied to the system until specifically authorized by the Manufacturer.

G. Provide all tools, network connections, devices and applications required to commission the control system.

H. Contractor shall provide the supports required for the lighting control components. Ascertain the structural reliability of supports provided under other Sections of the specification. Reinforce the walls as required to support wall-mounted dimming and relay panels.

3.2 COMMISSIONING

A. Contractor shall provide a complete and operational lighting control system that is calibrated to the satisfaction of the Owner, building manager, and occupants.

B. Factory Rep Inspection: When lighting control systems are completely installed and tested and final adjustments have been made to the satisfaction of the Contractor, systems shall be inspected by a factory-trained engineer representing the Manufacturer, in the presence of the Architect and the Owner. Architect shall schedule the inspection. Provide labor and tools as necessary for the final inspection and adjustments, whether the inspection is scheduled within or outside of normal working hours, at no additional cost to the Owner. If subsequent inspections are required due to significant failure of the Contractor to meet the requirements of the Specifications, or to prepare adequately for the inspection, Contractor will reimburse Architect for time and expenses, including travel costs, to make any subsequent inspections. Manufacturer's factory-trained engineer shall be present at any subsequent inspections. Promptly correct any deficiencies found during final inspection.

C. Control assignment verification: The Contractor shall verify that all zones, circuits, addresses, and panel assignments of the lighting system meet the specifications, construction documents, and Control Intent Narrative specified herein.

D. Initial Calibration: Controls shall be pre-calibrated at the factory by the Manufacturer, in the field by the Manufacturer Provided Technician, by the Contractor, or in combination, to the initial levels and settings indicated in the contract documents, or by any subsequent instructions provided during the shop drawing phase. If such settings are missing or unclear, the Contractor shall request clarification of the Architect before proceeding with installation. These initial settings shall be completed prior to the final calibration.

E. Final Calibration / Commissioning: Final adjustments, calibrations and commissioning shall be performed to the Owner's satisfaction, with the presence of the Architect, Lighting Designer, Owners Representative, and Manufacturer's Technician. Manufacturer's Factory Representative for the control systems shall be engaged by the Contractor. This shall involve at least visits, pre-arranged by the Contractor at least three weeks in advance so that Architect can be present for the calibration. If the equipment cannot be calibrated in a timely manner due to incomplete or incorrect work on the part of the Contractor, the Contractor is responsible for additional visits and the associated additional fees of the Manufacturer, Architect, and Lighting Designer.

F. The Manufacturer's Technician and Contractor, shall return to the site at least one (1) time in the next year to modify the settings, if requested.

G. Adjustments to calibrations and setting shall not be modified from those that have been established to meet prerequisites, energy analyses or mandatory provisions of Energy Codes, LEED or WELL Building criteria or credits, or similar base requirements of the project.

H. Documentation of the final settings established for all lighting controls shall be provided to the Owner and Architect within two weeks after calibration in digital format. This final Commissioning Report shall also be included in the O&M manual.

I. Post commissioning: The Manufacturer and Contractor shall return to the site within a period of eighteen to twenty-four months, as arranged. Verify or return the settings for all control components to those established in the final Commissioning Report or during a follow-up visit. Meet with the Owner and make requested modifications that do not increase energy consumption, affect quality of light, or violate the criteria of codes and standards established above. Repair or replace any control equipment that is inoperable or otherwise defective or unable to hold its calibration.

J. Manual: Assemble and submit, in digital PDF format and bound 8-1/2"x11" format, an Operation and Maintenance Manual. After corrections and approval by the Architect, this manual will be kept on site for reference use by facility maintenance personnel. Transfer of the final approved document will include a thorough walk-through and demonstration of equipment by the Contractor for facility personnel. The Architect shall schedule the transfer. The manual shall include the following:

1. Product technical documents and cut sheets;
2. Manufacturer and product Representative contacts;
3. Operation and calibration instructions for all components included in the installation.
4. Manual shall include as-built drawings from the lighting control systems Manufacturer as a paper record of the final settings;
5. Final settings and levels selected by the Architect;
6. Spare part listings;
7. 11x17 reduced drawings of all system assembled drawings needed to perform system maintenance;
8. Laminated short-cut guide outlining network access, system log-n process, system override activation and common troubleshooting.

K. Keys: Provide Owner with four (4) sets of keys for every lockable enclosure or cabinet during transfer of Operation and Maintenance Manual.

L. Training: At the Owner's convenience, the controls Manufacturer’s technician shall provide a minimum of two (2) hours, not to exceed eight (8) hours, of supplemental expertise and training concerning the installation, characteristics, operations and maintenance of the preset lighting control systems. Such training shall take place after the Contractor has provided the Architect and Owner with the approved Maintenance and Operation Manual mentioned above, and after all systems have been inspected and calibrated, as required above.

M. A second training session shall be provided six months after the first training session. Training sessions shall not exceed four working hours. Additional training shall be available upon request. Scheduling for training sessions shall be made in writing, 21 days prior to the time factory trained personnel are needed on the job site

N. Video: The Contractor shall video-tape the training session and provide the Owner with two (2) copies of the training video file on different devices. Alternative formats are acceptable if mutually agreed upon. Manufacturer’s training videos for the products may also be included if containing similar or supplemental information but shall not replace the requirement to videotape the actual training sessions. All control products must be represented in visual graphic or animated format.

O. Calibration of Lighting Controls:

1. All devices shall be calibrated by Manufacturer’s recommended method or wirelessly with remote control devices provided by Manufacturer. Provide one unit of all remote-control devices required to calibrate and modify the control system to the Owner at no additional cost to the project. If calibration requires the purchase of 3rd party equipment such as an iPhone, Contractor shall provide 3rd party equipment with the latest version of the application and the correct version of the operating system. Contractor is responsible for purchasing and coordinating delivery of any 3rd party equipment at the direction of Manufacturer. Manufacturer shall provide, with the specification

documents, a bill of materials for the exact make, model, and operating software required to run the latest version of the commissioning application. Commissioning hardware shall remain on location and be passed off to Owner after substantial completion.

2. Use calibration settings as designated in these specifications, appendices, Control Intent Narrative, programming matrix, or sequence of operation. If no calibration values are described in the contract documents, or there are discrepancies, request clarification by the Architect. Submit Manufacturer's default calibration settings during the submittal phase.
3. If devices are not performing to the satisfaction of the Owner, sensors shall be re-calibrated by the Manufacturer's technician on site at no added cost to Owner or Architect.
4. Wall-box dimmers: Dimmers shall be tested and fully operational, set to the correct load type, fade rate set to zero.
5. Occupancy Sensors:
   a. Contractor shall set occupancy sensors to medium sensitivity and 15-minute time delay at time of installation.
   b. All occupancy sensor system(s) shall be completely commissioned by the Manufacturer's technician, who will verify all adjustments and sensor placement.
6. On-Site Commissioning:
   a. Provide the Architect with at least with at least fifteen (15) working days written notification prior to each commissioning visit by the Manufacturer's technician.
   b. Prior to Owner move-in, but after commissioning of occupancy sensor system(s), a factory authorized technician shall provide training to the Owner's personnel in the adjustment and maintenance of the sensors. This training shall be in two separate sessions on days selected by the Architect, not exceed a total of four (4) hours.

P. Installation and Calibration of Daylight Sensors Open Loop Switching Only

1. The system shall be installed by the Contractor. The initial settings shall be set by the Manufacturer's technician during installation. The initial system settings as follows:
   a. Deadband – Set to 40%
   b. Time OFF Delay – Set to 30 minutes
   c. Time ON Delay – Set to 30 seconds
   d. Zone 'a' Setpoint: "Turn-on" to occur when daylight alone is less than 40 fc at desktop height (2'-6") at the mid-point of a bay with full height windows. "Turn-off" to occur when daylight exceeds 45 fc.
   e. Zone 'b' Setpoint: "Turn-on" to occur when daylight alone is less than 20 fc. "Turn-off" to occur when daylight exceeds 25 fc.
   f. Zone 'c' Setpoint: "Turn-on" to occur when system is activated. "Turn-off" to occur when system is deactivated.

Q. Energy Code Compliance

1. Where applicable, Contractor shall provide aid in the preparation and completion of a functional testing report or other documentation required for energy code compliance.

PART 4 - APPENDICES

4.1 GENERAL:

The appendices listed below are integral parts of the specifications and contract documents. If an Appendix is missing or incomplete, notify the Architect. Do not submit a bid based on incomplete information.

4.2 APPENDIX A – LIGHTING CONTROL INTENT NARRATIVE

Provide lighting control system components that satisfy the above specifications, as well as the Contract Drawings and meet the performance described in the Lighting Control Intent Narrative. If there are any discrepancies between these documents that are unresolved during the bid period, the more costly option will be considered as included in the bid prices.

4.3 APPENDIX B - CATALOGUE EXTRACTS FOR LIGHTING CONTROL SYSTEM COMPONENTS

Provide lighting control system components that satisfy the above specifications, as well as the Contract Drawings. If there are any discrepancies between the above specifications, the Contract Drawings, and the catalogue extracts that are unresolved during the bid period, the more costly option will be considered as included in the bid prices. The information in standard catalogue extracts are for general information only, and the product provided must meet all criteria specified herein.

End of Section

Section 23 09 23.30

ARCHITECTURAL LIGHTING CONTROL SYSTEMS – APPENDIX A

LIGHTING CONTROL INTENT NARRATIVE

1.1 GENERAL

A. The following describes the design intent of the interior and exterior lighting control system for Cornell Balch Hall, as reflected in the Contract Document drawings and documentation. This is intended as a summary of HLB's recommendations with the incorporation of Owner feedback and shall be used to guide the Electrical Engineer's preparation of the contract documents and specifications. If there are any discrepancies between these documents that are unresolved during the bid period, the costlier option shall be considered as included in the bid prices. It is also intended to inform the controls' manufacturers and the contractors during bidding, shop drawings, and installation, and to be used by the factory certified technicians for the final calibrations and fine-tuning of the system. Finally, it provides the Owner's Facility Manager with an explanation of why and how the system is expected to operate.

B. For this project, HLB has been advised to design to 2020 Energy Conservation Construction Code of New York State and provided city guidelines.

C. Refer to associated Lighting Controls documents specified here.

D. Control manufacturer shall substantiate conformance to the Specifications by submitting a written document included with the shop drawings, indicating that the equipment submitted meets each line item in the Specification and Lighting Control Intent Narrative, and if not, note any exceptions. Indicate how the proposed product exceptions still meet the intended performance described, specified or provided by the "basis of design." Submit all relevant UL file cards or test reports which cover the equipment submitted, to demonstrate compliance with the Specifications.

E. Coordination of all controls shall be vetted with architect, owner, engineer, lighting designer, AV consultant, contractor and manufacturer for optimal performance.

1.2 STRATEGIES

A. All lighting control devices in networked spaces shall connect to Building Automation Systems (BAS) specified and shall utilize a non-proprietary BACnet controls protocol.

1. Lighting control systems that provide a separate controller and use a BACnet interface shall not be accepted.
2. Spaces with local controls devices specified in Section 26 27 26 shall not be connected to BAS.

B. The BAS shall directly control all lighting control zones specified herein and shall provide astronomic timeclock functionality as required by code.

C. Multi-scene preset dimming with timeclock and override keypads. Provide dimming as required per fixture schedule.

D. Occupancy and vacancy automatic shut-off control. Contractor shall locate sensors per manufacturer optimal performance guidelines for complete coverage of space.

E. Partial-off dimming of corridors and stairwells to reduce energy consumption when the spaces are vacant while maintaining a safe and inviting environment.

F. All control faceplates shall be permanently labeled (engraved or etched). Label text shall be pre-approved by Owner.

G. All control panels, breakers, and relays related to lighting shall be clearly labeled to match the space designations and control zone designations shown in the Contract Documents. Final switch and preset control locations shall be reviewed by Architect and Owner.

H. Electrical Engineer shall confirm lighting that is required by Code to provide egress lighting or remain on after typical hours of occupancy.

I. All fixtures that are on emergency shall be capable of being controlled and dimmed to various scenes and zones for regular use.

J. Manufacturer shall provide integration and programming services for a complete and functional system as specified herein.

K. Allow for portable control device, as required for programming and commissioning.

L. Programming of high-end trim to be implemented on first day of occupancy. High end trim percentages shall be provided by Owner during programming.

1.3 DAYLIGHT CONTROL EQUIPMENT

A. Daylight sensor(s) shall be provided to allow continuous dimming in each daylit space when daylight is available, as required by code. Fixtures in daylit zones shall be independently controlled in relation to fixture types that are not in the same daylit zones.

1. For linear luminaires with contiguous segments that span daylit and non-daylit zones, the initial programming of control zone settings shall be as follows: Segment(s) in sidelit zones shall be set at lowest light output (15% max.) when daylight is available to provide a visually acceptable appearance when compared to a contiguous segment in a non-daylit zone that is at full light output.

B. Photosensor settings shall adjust the lighting levels based upon the natural daylight entering the space. Daylight zones shall be automatically continuously dimmed to a minimum of 15% of overall output via daylighting sensors.

C. After hours occupancy sensors shall control lighting during times provided by the Owner. Lighting in these spaces shall be controlled by timeclock for all other times.

1.4 EMERGENCY/ EGRESS LIGHTING CONTROL

A. Refer to Electrical Drawings and specifications for egress lighting, emergency lighting, exit lighting, and emergency lighting controls as specified by Electrical Engineer.

1.5 WARRANTY

A. Provide a minimum 2-year warranty on the lighting control system.

1.6 STUDENT BEDROOM, FACULTY APARTMENT, ELECTRICAL ROOM WITH LOCAL CONTROLS

A. Zones
   1. Refer to zoning on plan.

B. Switched Control
   1. On
   2. Off

C. Control Stations
   1. Local switches located by the entrance/s to toggle control of lighting.

D. Sensors and Management
   1. None

1.7 BACK OF HOUSE SPACES WITH LOCAL CONTROLS

A. Zones
   1. Refer to zoning on plan.

B. Switched Control
   1. On
   2. Off

C. Control Stations
   1. Local switches located by the entrance/s to toggle control of lighting.

D. Sensors and Management
   1. Vacancy Sensors: Lighting shall remain off until turned on by control station. Lighting shall remain on until manually turned off by occupant or automatically after a 15-minute timeout if no occupancy has been detected.

1.8 EXTERIOR SITE AND BUILDING MOUNTED LIGHTING

A. Zones
   1. Refer to zoning on plan.

B. Programmed Scenes
   1. Day
   2. Night

C. Control Stations
   1. Building Automation System specified by Electrical Engineer.

D. Sensors and Management
   1. Timeclock Control / Photosensor Switching: Lighting shall be turned off by photosensor and on by astronomic timeclock 1 hour before dusk on all days the building is typically occupied. Timeclock shall keep the lights on until photosensor detects sufficient daylight to shut off lighting.
   2. Photosensor Dimming: Lighting shall dim in response to available daylight.
   3. BAS Integration: Lighting shall be controlled by Building Automation System. Provide integration support to contractor with BAS scope.

1.9 BATHROOM AND SUPPORT SPACE

A. Zones
   1. Refer to zoning on plan.

B. Programmed Scenes
   1. On
   2. 50%
   3. Off

C. Control Stations
   1. Dimming switches located by the entrance/s to toggle control of lighting.
   2. Building Automation System specified by Electrical Engineer.

D. Sensors and Management
   1. BAS Integration: Lighting shall be controlled by Building Automation System. Provide integration support to contractor with BAS scope.
   2. After Hours, Occupancy Sensors: Lighting shall turn on when occupancy is detected. The lighting shall automatically dim to 20% output after a 15-minute timeout if no occupancy has been detected. Each bathroom stall shall be provided with an occupancy sensor.
   3. Timeclock Control: Lighting shall turn on during regular occupied hours. After hours lighting shall dim to a programmed level. The timeclock shall transfer control to occupancy sensors after hours.

1.10 CIRCULATION, VESTIBULE, AND CORRIDOR

A. Zones
   1. Refer to zoning on plan.

B. Programmed Scenes
   1. On
   2. 50%
   3. 20%
   4. Off

C. Control Stations
   1. Building Automation System specified by Electrical Engineer.

D. Sensors and Management
   1. BAS Integration: Lighting shall be controlled by Building Automation System. Provide integration support to contractor with BAS scope.
   2. After Hours, Occupancy Sensors**:** Lighting shall turn on to 50% after hours when occupancy is detected and automatically dim to 20% output after a 15-minutes timeout if no occupancy has been detected.
   3. Timeclock Control: Lighting shall turn on during regular occupied hours. After hours lighting shall dim to a programmed level. The timeclock shall transfer control to occupancy sensors after hours.

1.11 STAIRS

A. Zones
   1. Refer to zoning on plan.

B. Programmed Scenes
   1. On
   2. 50%
   3. Off

C. Control Stations
   1. Building Automation System specified by Electrical Engineer.

D. Sensors and Management
   1. BAS Integration: Lighting shall be controlled by Building Automation System. Provide integration support to contractor with BAS scope.
   2. Timeclock Control: Lighting shall turn on during regular occupied hours. The timeclock shall transfer control to occupancy sensors after hours.

3. Occupancy Sensors**:** Lighting shall turn on to full after hours when occupancy is detected and automatically dim to 50% output after a 15-minutes timeout if no occupancy has been detected.

1.12 BUILDING LOUNGE

A. Zones
   1. Refer to zoning on plan.

B. Programmed and Control Station Scenes
   1. On
   2. Preset 1
   3. Preset 2
   4. Preset 3
   5. Off

C. Control Stations
   1. Multi-scene preset control located in a central location. Control shall have 3 scenes and allow from lighting control zones to be controlled independently of preset settings. Scenes shall be programmed to be triggered by timeclock and shall override any changes made locally.
   2. Dimming switches located by the entrance/s to toggle control of lighting.
   3. Building Automation System specified by Electrical Engineer.

D. Sensors and Management
   1. BAS Integration: Lighting shall be controlled by Building Automation System. Provide integration support to contractor with BAS scope.
   2. After Hours, Occupancy Sensors**:** Occupancy sensors shall turn on lighting to 100% after hours when occupancy is detected. The lighting shall automatically dim to 20% output when 15 minutes of no occupancy has been detected.
   3. Timeclock Control / Photosensors: Lighting shall turn on at dusk on all days identified by Owner. Timeclock shall keep the lights on preset level until after hours. Lighting in daylight zones shall maintain a setpoint illumination.

1.13 HISTORICAL LOUNGE

A. Zones
   1. Refer to zoning on plan.

B. Programmed and Control Station Scenes
   1. On
   2. Preset 1
   3. Preset 2

4. Preset 3
5. Preset 4
6. Off

C. Control Stations
1. Multi-scene preset control located in a central location. Control shall have 4 scenes and allow from lighting control zones to be controlled independently of preset settings. Scenes shall be programmed to be triggered by timeclock and shall override any changes made locally.
2. Dimming switches located by the entrance/s to toggle control of lighting.
3. Building Automation System specified by Electrical Engineer.

D. Sensors and Management
1. BAS Integration: Lighting shall be controlled by Building Automation System. Provide integration support to contractor with BAS scope.
2. Photosensors: Photosensor settings shall adjust the lighting levels based upon the natural daylight entering the space.
3. Occupancy Sensors**: L**ighting shall automatically shut off when 15 minutes of no occupancy has been detected.

1.14 MUSIC ROOM

A. Zones
1. Refer to zoning on plan.

B. Programmed Scenes
1. On
2. 50%
3. Off

C. Control Stations
1. Dimming switches located by the entrance/s to toggle control of lighting.
2. Building Automation System specified by Electrical Engineer.

D. Sensors and Management
1. BAS Integration: Lighting shall be controlled by Building Automation System. Provide integration support to contractor with BAS scope.
2. Vacancy Sensors: Lighting shall remain off until turned on by control station. Lighting shall remain on until manually turned off by occupant or automatically after a 15-minute timeout if no occupancy has been detected.

1.15 MULTIPURPOSE ROOM

A. Zones
   1. Refer to attached zoning diagram.

B. Programmed Scenes
   1. On
   2. 50%
   3. Off

C. Control Stations
   1. Dimming switches located by the entrance/s to toggle control of lighting.
   2. Building Automation System specified by Electrical Engineer.

D. Sensors and Management
   1. BAS Integration: Lighting shall be controlled by Building Automation System. Provide integration support to contractor with BAS scope.
   2. Vacancy Sensors: Lighting shall remain off until turned on by control station. Lighting shall remain on until manually turned off by occupant or automatically after a 15-minute timeout if no occupancy has been detected.

1.16 KITCHEN

A. Zones
   1. Refer to zoning on plan.

B. Programmed Scenes
   1. On
   2. 50%
   3. Off

C. Control Stations
   1. Dimming switches located by the entrance/s to toggle control of lighting.
   2. Building Automation System specified by Electrical Engineer.

D. Sensors and Management
   1. BAS Integration: Lighting shall be controlled by Building Automation System. Provide integration support to contractor with BAS scope.
   2. Vacancy Sensors: Lighting shall remain off until turned on by control station. Lighting shall remain on until manually turned off by occupant or automatically after a 15-minute timeout if no occupancy has been detected.

1.17 LAUNDRY ROOM

A. Zones

1. Refer to zoning on plan.

B. Programmed Scenes
   1. On
   2. 50%
   3. Off

C. Control Stations
   1. Dimming switches located by the entrance/s to toggle control of lighting.
   2. Building Automation System specified by Electrical Engineer.

D. Sensors and Management
   1. BAS Integration: Lighting shall be controlled by Building Automation System. Provide integration support to contractor with BAS scope.
   2. Vacancy Sensors: Lighting shall remain off until turned on by control station. Lighting shall remain on until manually turned off by occupant or automatically after a 15-minute timeout if no occupancy has been detected.

November 05, 2021

Lighting Controls Tunnel

Student Bedrooms, Faculty Apartment, Electrical rooms

Local on/off control

Bathrooms, Student Kitchens and Support Spaces

Occupancy sensor with local on/50%/off control and connection to BAS for control and energy reporting.

Student Lounge and Historic Lounge

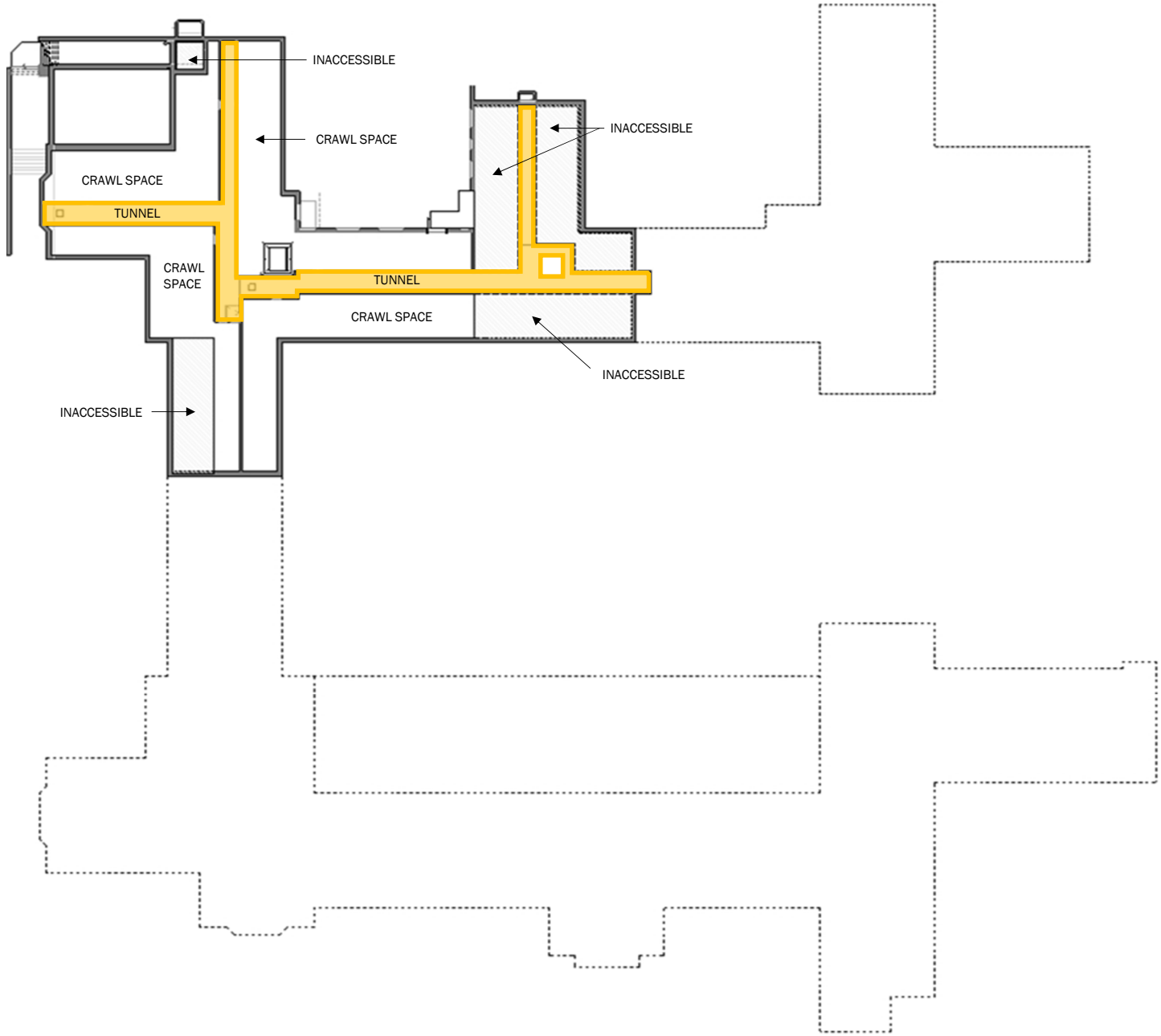
Occupancy and daylight sensor with local preset / zone control and connection to BAS for control and energy reporting.

Corridors and Stairs

Occupancy sensor and connection to BAS for control and energy reporting.

Back of House

Vacancy sensor with on/off control.



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Lighting Controls 1st Floor

Student Bedrooms, Faculty Apartment, Electrical rooms

Local on/off control

Bathrooms, Student Kitchens and Support Spaces

Occupancy sensor with local on/50%/off control and connection to BAS for control and energy reporting.

Student Lounge and Historic Lounge

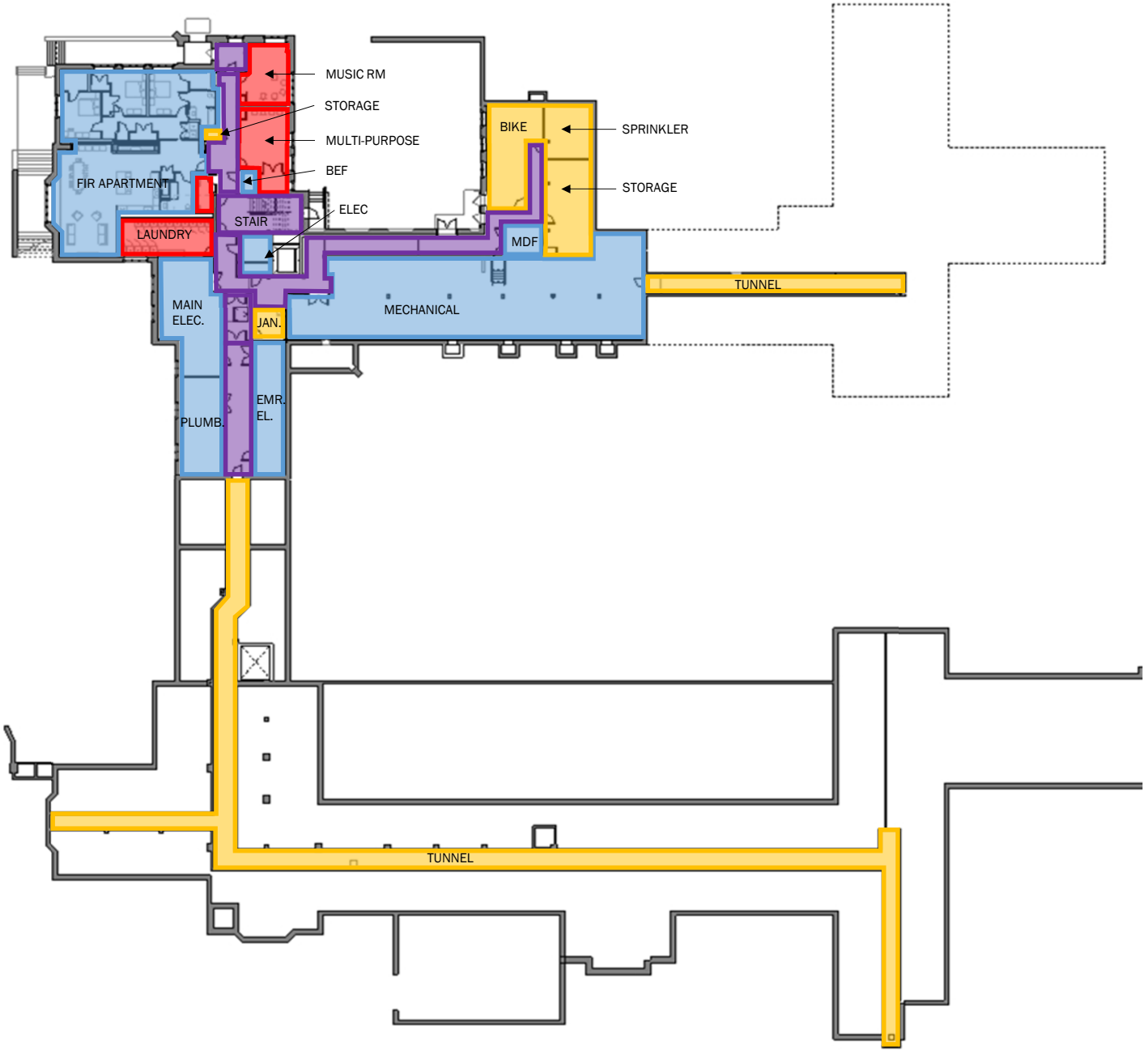
Occupancy and daylight sensor with local preset / zone control and connection to BAS for control and energy reporting.

Corridors and Stairs

Occupancy sensor and connection to BAS for control and energy reporting.

Back of House

Vacancy sensor with on/off control.



November 05, 2021

Lighting Controls 2nd Floor

Student Bedrooms, Faculty Apartment, Electrical rooms

Local on/off control

Bathrooms, Student Kitchens and Support Spaces

Occupancy sensor with local on/50%/off control and connection to BAS for control and energy reporting.

Student Lounge and Historic Lounge

Occupancy and daylight sensor with local preset / zone control and connection to BAS for control and energy reporting.

Corridors and Stairs

Occupancy sensor and connection to BAS for control and energy reporting.

Back of House

Vacancy sensor with on/off control.

November 05, 2021

Lighting Controls 3rd Floor

Student Bedrooms, Faculty Apartment, Electrical rooms

Local on/off control

Bathrooms, Student Kitchens and Support Spaces

Occupancy sensor with local on/50%/off control and connection to BAS for control and energy reporting.

Student Lounge and Historic Lounge

Occupancy and daylight sensor with local preset / zone control and connection to BAS for control and energy reporting.

Corridors and Stairs

Occupancy sensor and connection to BAS for control and energy reporting.

Back of House

Vacancy sensor with on/off control.

November 05, 2021

Lighting Controls
4th Floor

Student Bedrooms, Faculty Apartment, Electrical rooms

Local on/off control

Bathrooms, Student Kitchens and Support Spaces

Occupancy sensor with local on/50%/off control and connection to BAS for control and energy reporting.

Student Lounge and Historic Lounge

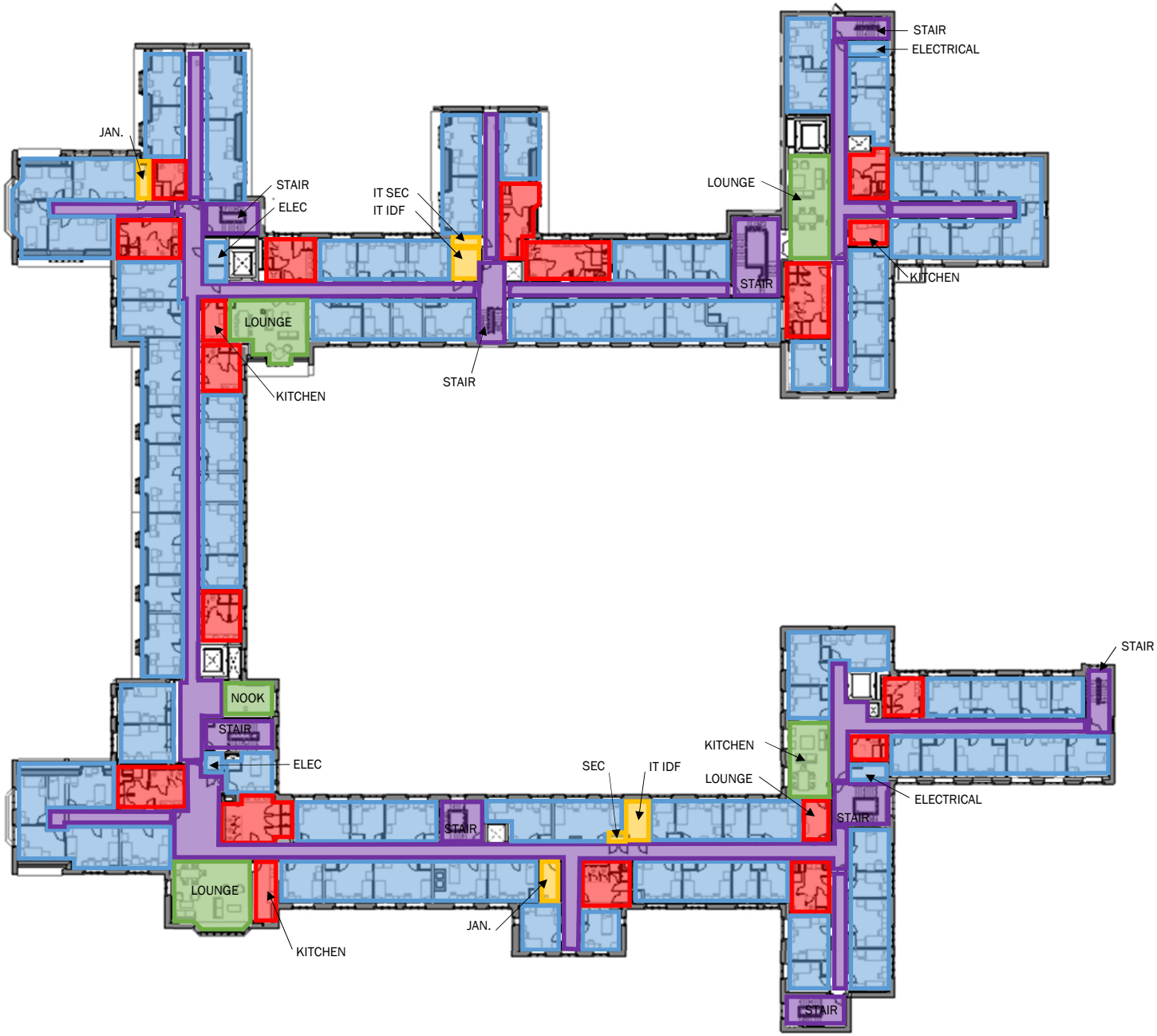
Occupancy and daylight sensor with local preset / zone control and connection to BAS for control and energy reporting.

Corridors and Stairs

Occupancy sensor and connection to BAS for control and energy reporting.

Back of House

Vacancy sensor with on/off control.



November 05, 2021

Lighting Controls
5th Floor

Student Bedrooms, Faculty Apartment, Electrical rooms

Local on/off control

Bathrooms, Student Kitchens and Support Spaces

Occupancy sensor with local on/50%/off control and connection to BAS for control and energy reporting.

Student Lounge and Historic Lounge

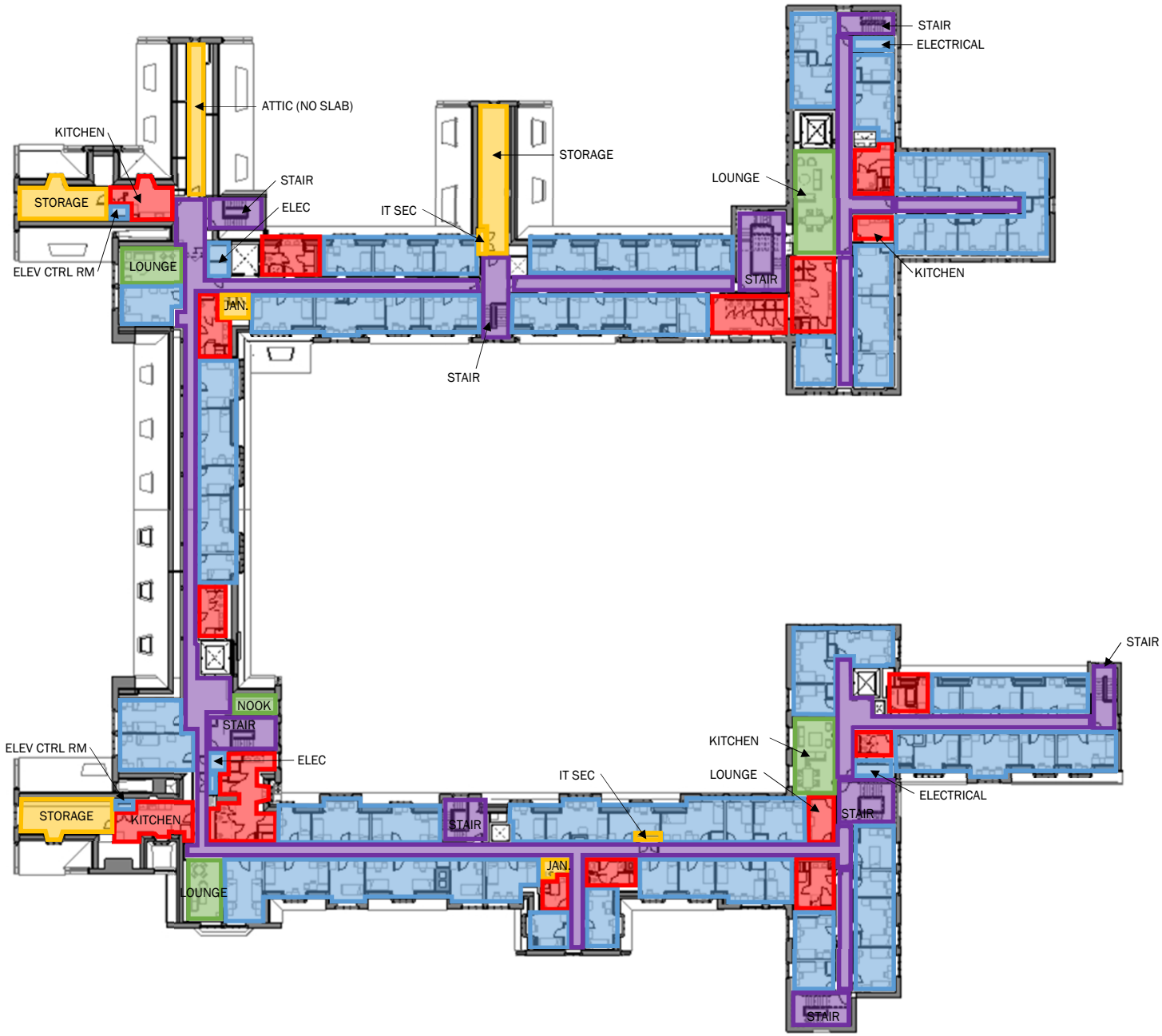
Occupancy and daylight sensor with local preset / zone control and connection to BAS for control and energy reporting.

Corridors and Stairs

Occupancy sensor and connection to BAS for control and energy reporting.

Back of House

Vacancy sensor with on/off control.



November 05, 2021

Lighting Controls
6th Floor

Student Bedrooms, Faculty Apartment, Electrical rooms

Local on/off control

Bathrooms, Student Kitchens and Support Spaces

Occupancy sensor with local on/50%/off control and connection to BAS for control and energy reporting.

Student Lounge and Historic Lounge

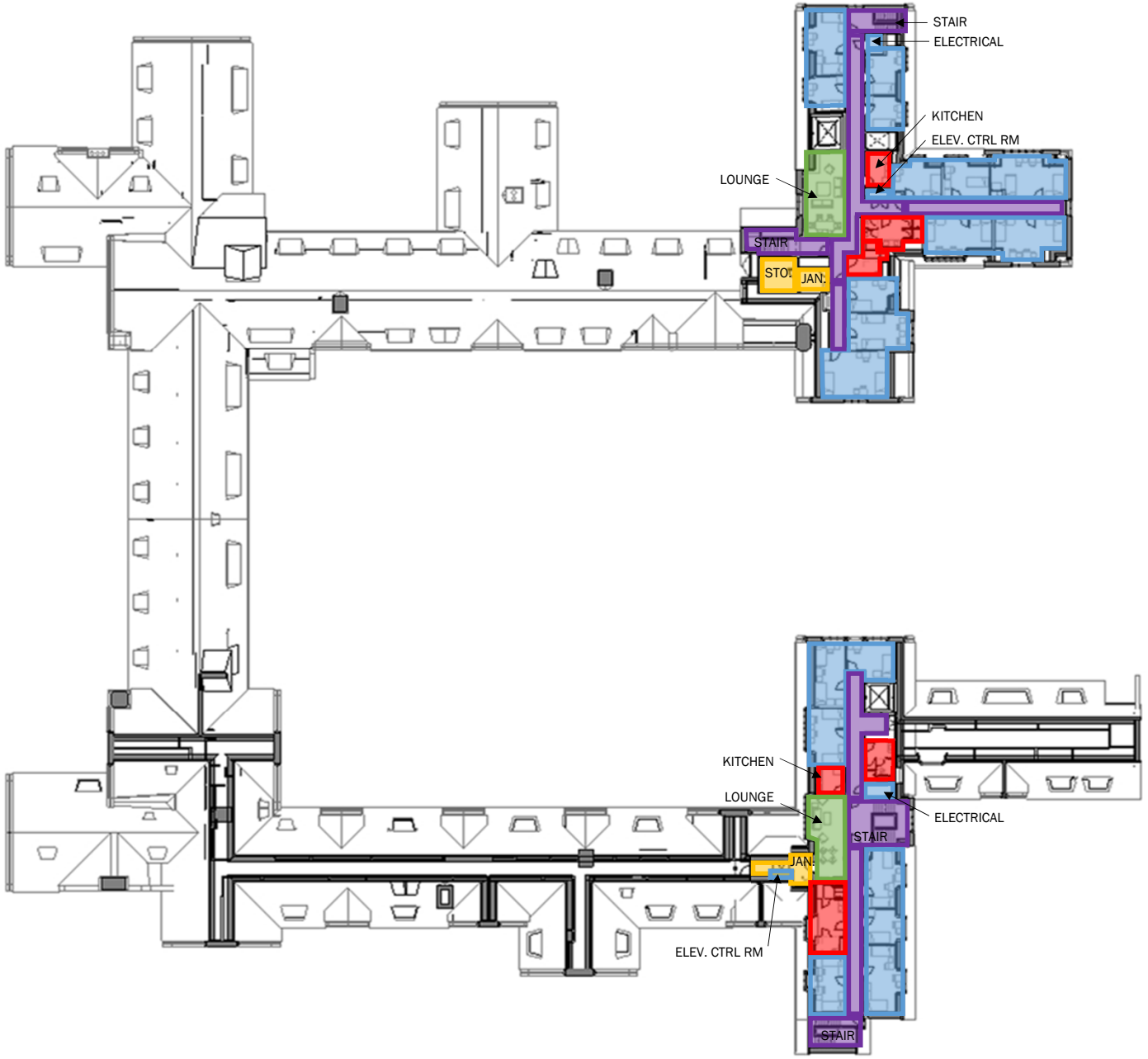
Occupancy and daylight sensor with local preset / zone control and connection to BAS for control and energy reporting.

Corridors and Stairs

Occupancy sensor and connection to BAS for control and energy reporting.

Back of House

Vacancy sensor with on/off control.



Section 23 09 23.30

ARCHITECTURAL LIGHTING CONTROL SYSTEMS – APPENDIX B

CATALOGUE EXTRACTS FOR LIGHTING CONTROL SYSTEM COMPONENTS

WATTSTOPPER®

SENSORS | OCCUPANCY & VACANCY

legrand®

LOW VOLTAGE DUAL TECHNOLOGY CEILING SENSORS | DT-300 SERIES

Architecturally appealing low-profile appearance

Walk-through mode increases savings potential

Ultrasonic diffusers give more comprehensive coverage

Plug terminal wiring for quick and easy installation

Accepts low-voltage switch input for manual-on operation

Supports automatic or manual-on operation

Description

The DT-300 Series Dual Technology Ceiling Sensors combine the benefits of passive infrared (PIR) and ultrasonic technologies to detect occupancy. Sensors have a flat, unobtrusive appearance and provide 360 degrees of coverage.

Operation

Low voltage DT-300 Series sensors utilize a Wattstopper power pack to turn lights on when both PIR and ultrasonic technologies detect occupancy. They can also work with a low voltage switch for manual-on operation. PIR technology senses motion via a change in infrared energy within the controlled area, whereas ultrasonic uses 40KHz high frequency ultrasound. Once lights are on, detection by either technology holds them on. When no occupancy is detected for the length of the time delay, lights turns off. DT-300 Series Sensors can also be set to trigger lights on when either technology or both detect occupancy, or to require both technologies to hold lighting on.

Time Delay Options

The DT-300 is factory set for a 20 minute time delay, ideal for both energy savings and user satisfaction in most applications. Installers can quickly select other fixed time delays (5, 10, 15 or 30 minutes) via DIP switches. Fixed time delays eliminate the occupant dissatisfaction associated with an automatically adjusted time delay option, and reduce callbacks. Walk-through mode may be enabled for added energy savings in spaces with frequent transient traffic.

Applications

DT-300 Series Dual Technology Sensors have the flexibility to work in a variety of applications, where one technology alone could cause false triggers. Ideal applications include classrooms, open office spaces, large offices and computer rooms. The DT-300 Series mounting system makes them easy to install in ceiling tiles or to junction boxes, providing the flexibility to be used in a wide range of spaces.

Features

- Advanced control logic based on RISC microcontroller provides:
  - Detection Signature Processing eliminates false triggers and provides immunity to RFI and EMI
  - Walk-through mode turns lights off three minutes after the area is initially occupied – ideal for brief visits such as mail delivery
  - Available with built-in light level sensor featuring simple, one-step setup
- Sensors work with low-voltage momentary switches to provide manual control
- Patented ultrasonic diffusion technology spreads coverage to a wider area
- LEDs indicate occupancy detection
- Uses plug terminal wiring system for quick and easy installation
- Eight occupancy logic options provide the ability to customize control to meet application needs
- Available with isolated relay for integration with BAS or HVAC
- BAA/TAA-compliant models available
- Sensor coverage tested to NEMA Guide Publication WD 7-2000

PROJECT		LOCATION/ TYPE	

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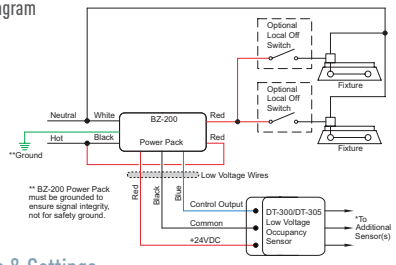
Specifications

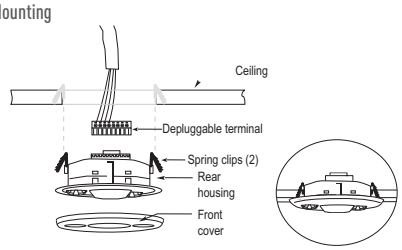
- 18–28 VDC/VAC
- Current Consumption @24VDC/VAC
  - DT-300: 25mA (DC)/74mA (AC)
  - DT-305: 16mA (DC)/69mA (AC)
- Ultrasonic frequency: 40kHz
- Time delays: 5, 10, 15, 20, or 30 minutes, Walk-through/Test Modes
- Sensitivity adjustment: High/low (PIR); variable with trim pot (ultrasonic)
- Built-in light level sensor: 10 to 300 footcandles (107.6 to 3,229.2 lux)
- Low-voltage, momentary switch input for manual on or off operation
- DT-300 contains an isolated relay with N/O and N/C outputs; rated for 1 Amp @ 30 VDC/VAC
- Multi-level Fresnel lens provides 360° coverage
- Mounting options: ceiling tile; 4" octagonal J-box, 1.5" deep
- Max DT-300s per power pack: B=2, BZ=6
  Max DT-305s per power pack: B=3, BZ=7
- Dimensions: 4.50" diameter x 1.02" deep (114.3mm x 25.9mm)
- UL and cUL listed
- Five year warranty

Wiring & Mounting

Wiring Diagram

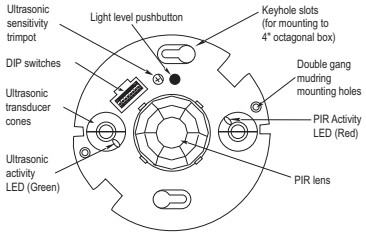


Ceiling Mounting



Controls & Settings

Product Controls



DIP Switch Settings

Feature	Switch#
Time Delay	1 2 3
Test Mode/20 min	↓ ↓ ↓
30 seconds	↓ ↓ ↑
5 minutes	↓ ↑ ↓
10 minutes	↓ ↑ ↑
15 minutes	↑ ↓ ↓
20 minutes	↑ ↓ ↑ ◀
25 minutes	↑ ↑ ↓
30 minutes	↑ ↑ ↑

Walk-Through	4
Enabled	↑
Disabled	↓ ◀

PIR Sensitivity	5
Minimum	↑
Maximum	↓ ◀

Occupancy Logic	Settings	6	7	8
	Standard	↓	↓	↓ ◀
	Option 1	↑	↓	↓
	Option 2	↓	↑	↓
	Option 3	↑	↑	↓
	Option 4	↓	↓	↑
	Option 5	↑	↓	↑
	Option 6	↓	↑	↑
	Option 7	↑	↑	↑

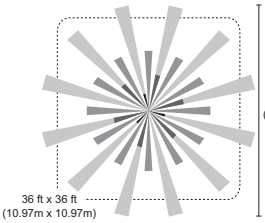
Occupancy Logic	Trigger	Initial Occupancy	Maintain Occupancy	Re-trigger (seconds duration)
	Standard	Both	Either	Either(5)
	Option 1	Either	Either	Either(5)
	Option 2	PIR	Either	Either(5)
	Option 3	Both	PIR	Both(5)
	Option 4	PIR	PIR	PIR(5)
	Option 5	Either	PIR	Either(5)
	Option 6	Man.	Either	Either(30)
	Option 7	Man.	PIR	Both(30)

◀ = Factory Setting
↑ = ON
↓ = OFF

The control technology (occupancy logic) is selectable. The default setting requires both technologies to trigger on, either to hold on, and is recommended for most applications.

Coverage

Coverage Pattern



Coverage shown is maximum and represents half-step walking motion. Under ideal conditions, coverage for half-step walking motion can reach up to 1000 ft².

Ordering Information

Catalog #	Voltage	Current	Coverage	Features
☐ DT-300 ☐ DT-300-U	24VDC/VAC	25mA (DC)/ 74mA (AC)	up to 1000 ft² (92.9 m²	Isolated relay, light level
☐ DT-305 ☐ DT-305-U	24 VDC/VAC	16mA (DC)/ 69mA (AC)	up to 1000 ft² (92.9 m²	

Sensors are white and use Wattstopper power packs. Current consumption can be slightly higher when only one sensor per power pack is used.

-U = BAA/TAA compliant; product is compliant with Buy American Act and Trade Agreement Act

WATTSTOPPER®

DIGITAL LIGHTING MANAGEMENT | DAYLIGHTING SENSORS

legrand®

MULTI-ZONE SWITCHING AND DIMMING OPEN LOOP PHOTOSENSOR

LMLS-500

Daylight responsive on/off, bi-level, tri-level or dimming control for up to three lighting zones

Extended tube model accommodates thicker ceiling materials

60 degree spatial response for optimal detection of daylight contribution

Automatic setpoint recommendations; optional hold off setting to maximize energy savings

Photodiode corrected to match the photopic response of the human eye

Can be calibrated in any daylight condition

Description

The LMLS-500 is an open loop, multi-zone photosensor that measures the daylight contribution in order to automatically switch or dim up to three zones of lighting. It is part of a Digital Lighting Management (DLM) system and sends light level signals to control loads connected to DLM on/off or dimming room controllers. The LMLS-500 has a photodiode with an extended range of 1-6,553 footcandles (fc), and photopic correction to mimic the human eye, for precise measurement of visible light.

Operation

The LMLS-500 operates on Class 2 power supplied to a DLM local network by one or more DLM room controllers. Daylighting loads are assigned using an LMCT-100 wireless configuration tool. Following a quick initial setup, the LMLS-500 monitors the daylight contribution through a window or skylight and works with the room controller(s) to maintain design light levels in each lighting zone. Wattstopper's exclusive control algorithm uses on/off or dimming setpoints and other control parameters to establish the correct light levels throughout the day regardless of changing daylight contribution.

Simplified Setup and Configuration

The LMLS-500 is set up by entering the daylight and the workplane illuminance into an LMCT-100 wireless configuration tool. This handheld device then automates the calibration process, and recommends setpoints for easy completion of the setup process. The LMCT-100 may be used to adjust setpoints and other parameters including hold off functionality. Adjustable switching parameters include on and off setpoints and time delays. The off setpoint can be adjusted to a value of 25, 50 (default), 75, or 100 percent above the on setpoint. Adjustable dimming parameters include a setpoint, ramp up and down rates and a cut-off time delay. Electric lights can be turned off (default) or dimmed to a user-selectable minimum level when daylight contribution is abundant.

Applications

The LMLS-500 photosensor is recommended for open offices, cafeterias, classrooms, warehouses and any other indoor spaces with daylight contribution. It is designed to measure only daylight, not electric light, and can be mounted in a light well under a skylight, or on a ceiling for sidelighting applications. Each of the three control zones can initiate on/off switching, bi-level or tri-level step switching or step dimming, or continuous dimming.

Features

- Digital Lighting Management components plug together on a free-topology Cat 5e DLM local network
- Test mode override of programmed time delay allows easy verification of selected settings
- Load status verification allows confirmation and testing of controlled load
- Infrared (IR) transceiver for wireless configuration and control
- Compatible with DLM wall switches for manual override, if desired
- LED status indicators
- Mounting options for toplit or sidelit applications
- Complies with California Title 24, Section 119 requirements
- The product meets the materials restrictions of RoHS
- BAA/TAA-compliant models available

PROJECT		LOCATION/ TYPE	

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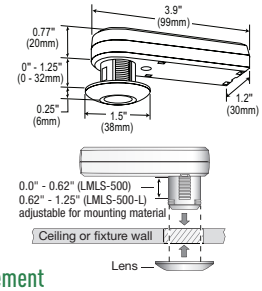
Specifications

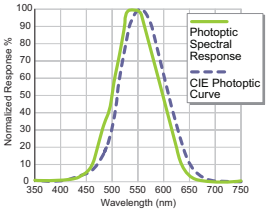
- Input voltage: 24VDC from DLM local network
- Current consumption: 7mA
- DLM local network connection: 1 RJ45 port
- Digital multi-band photodiode with extended range: 1–6,553 fc (10–70,536 lux)
- Spatial response: 60°
- LED status and configuration indicators
- Infrared (IR) transceiver
- Weight: 1.4 oz (40 g)
- Operating conditions: for indoor use only; 32-131°F (0–55°C); less than 90% RH, non-condensing
- UL and cUL listed
- FCC part 15 compliant
- Five year warranty

Dimensions & Response

Product Dimensions



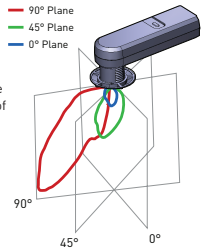
Spectral Response



The photodiode detects just visible light, which ensures accurate lighting control.

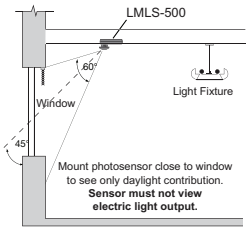
Spatial Response

Focused response allows detection of daylight only.

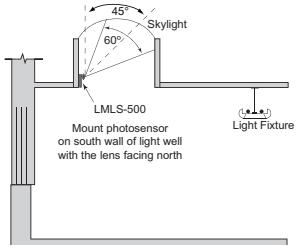


Placement

Sidelight Applications



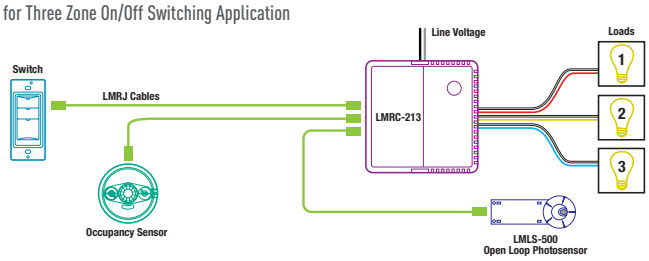
Skylight Applications



Connecting

Sample Connecting Diagram for Three Zone On/Off Switching Application

Plug DLM local network components together in any configuration using Cat 5e cables with RJ45 connectors.



Ordering Information

Catalog #		Description
☐	LMLS-500	Digital Multi-zone On/Off and Dimming Open Loop Photosensor
☐	LMLS-500-U	Digital Multi-zone On/Off and Dimming Open Loop Photosensor, BAA/TAA compliant*
☐	LMLS-500-L	Digital Multi-zone On/Off and Dimming Open Loop Photosensor with extended tube
☐	LMLS-MB1	Photosensor mounting bracket for J-box mounting
☐	LMLS-MB2	Photosensor mounting bracked for wall mount applications
☐	LMCT-100	Digital Wireless Configuration Tool

*Product is compliant with Buy American Act and Trade Agreement Act

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Pub. No. 27399r1 Rev. 10/2017

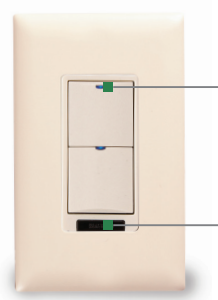
WATTSTOPPER® DIGITAL LIGHTING MANAGEMENT | PERSONAL CONTROLS legrand®

WALL SWITCHES | LMSW-100 SERIES

Low voltage pushbutton switches for control of multiple loads

Components of Digital Lighting Management integrated control system

Plug to other components using Cat 5e cables with RJ45 connectors eliminating wiring errors



Customizable buttons with LED status indicators

IR transceiver for wireless configuration and remote control

Plug n' Go automatic configuration and Push n' Learn for personalization

Description

LMSW-100 Series Wall Switches are low voltage devices for energy-saving manual on/off control of one or more loads from one or more locations. They are part of a Digital Lighting Management (DLM) system and can control any load(s) connected to DLM room controllers.

Operation

LMSW-100 Series Switches operate on Class 2 power supplied to a DLM local network by one or more room controllers. The switches send a digital signal for on or off whenever a pushbutton is pressed by a user. Plug n' Go™ automatic configuration assigns each load to a switch button upon system startup. If the number of buttons equals the number of loads, each button operates one load. If there are more loads than buttons, the last button controls multiple loads. Any extra buttons are unassigned. When multiple switches are installed, default operation is for multi-way control; each switch controls all of the loads on the system. Button assignments may be quickly reconfigured using Push n' Learn™. Button configuration may be changed from load control to scene control using DLM configuration tools.

Button Features and IR Communications

An LED shows the status of the load(s) or scene assigned to each button on a switch. Switches are available with one, two, three, four or eight buttons. When an unassigned button is pressed, the LED will blink. Each button (in a two or more button switch) can dim the load up or down. Each switch may be personalized in the field with custom-engraved buttons. The IR transceiver in each LMSW-100 Series Wall Switch allows two-way communication for both wireless system configuration and operation.

Applications

LMSW-100 Series Wall Switches are recommended for virtually all applications, including offices, conference rooms and classrooms. They are ideal for any area where manual on/off control is desired. They are also perfect for applications requiring multi-way control. LMSW-100 Series Switches increase energy savings and improve the return on investment of any Digital Lighting Management system.

Features

- Hidden configuration button for easy access to Push n' Learn
- Digital Lighting Managment components plug together on a free-topology Category 5e DLM local network
- Infrared (IR) transceiver for wireless configuration and control
- Sleek single gang devices fit decorator wall plates; 1-, 2-, 3-, 4-, and 8-button models
- Each button can control individual or multiple loads, or one scene; LED indicates status
- Each switch button can be used to dim the load (except for LMSW-101)
- Switches may be used for multi-way control
- Six color options and custom engraving options; standard buttons may be replaced in the field
- The product meets the materials restrictions of RoHS
- BAA/TAA-compliant models available

PROJECT		LOCATION/ TYPE	

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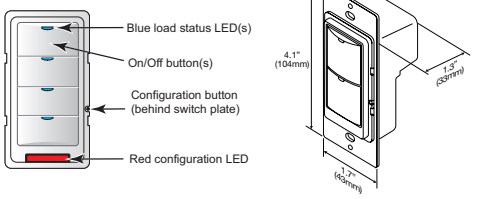
Specifications

- Input voltage: 24VDC from DLM local network
- Current consumption: 5mA
- DLM local network connection: 2 RJ45 ports
- 1, 2, 3, 4 or 8 control buttons, each with LED status indicator
- Hidden configuration button to access
- Push n˙ Learn
- Infrared (IR) transceiver
- Operating conditions: for indoor use only; 32-131°F (0-55°C); 5-95% RH, non-condensing
- UL and cUL listed
- FCC part 15 compliant
- Five year warranty

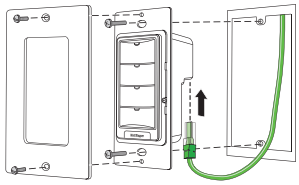
Controls & Mounting

Product Controls, Dimensions and Models



LMSW-101 LMSW-102 LMSW-103 LMSW-104 LMSW-108

Mounting

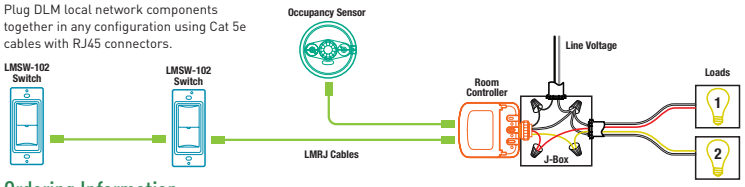


LMSW-100 Series Switches fit in standard single gang boxes.

Connecting

Sample Connection Diagram with Multi-way Bi-level Control

Plug DLM local network components together in any configuration using Cat 5e cables with RJ45 connectors.



Ordering Information

Catalog #	Color	Description
LMSW-101-W	White	1-Button Wall Switch
LMSW-101-LA	Light Almond	
LMSW-101-I	Ivory	
LMSW-101-G	Grey	
LMSW-101-B	Black	
LMSW-101-R	Red	
LMSW-101-W-U	White	1-Button Wall Switch, BAA/TAA-compliant*
LMSW-101-I-U	Ivory	
LMSW-102-W	White	2-Button Wall Switch
LMSW-102-LA	Light Almond	
LMSW-102-I	Ivory	
LMSW-102-G	Grey	
LMSW-102-B	Black	
LMSW-102-R	Red	
LMSW-102-W-U	White	2-Button Wall Switch, BAA/TAA-compliant*
LMSW-102-I-U	Ivory	
LMSW-103-W	White	3-Button Wall Switch
LMSW-103-LA	Light Almond	
LMSW-103-I	Ivory	
LMSW-103-G	Grey	
LMSW-103-B	Black	
LMSW-103-R	Red	
LMSW-103-W-U	White	3-Button Wall Switch, BAA/TAA-compliant*
LMSW-103-I-U	Ivory	
LMSW-104-W	White	4-Button Wall Switch
LMSW-104-LA	Light Almond	
LMSW-104-I	Ivory	
LMSW-104-G	Grey	
LMSW-104-B	Black	4-Button Wall Switch
LMSW-104-R	Red	
LMSW-104-W-U	White	4-Button Wall Switch, BAA/TAA-compliant*
LMSW-104-I-U	Ivory	
LMSW-108-W	White	8-Button Wall Switch
LMSW-108-LA	Light Almond	
LMSW-108-I	Ivory	
LMSW-108-G	Grey	
LMSW-108-B	Black	
LMSW-108-R	Red	
LMSW-108-W-U	White	8-Button Wall Switch, BAA/TAA-compliant*
LMSW-108-I-U	Ivory	
LMCT-100-2	Digital Wireless Configuration Tool	

Note: Switches do not include face plates. Order decorator style plate separately.

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*Product is compliant with Buy American Act and Trade Agreement Act

Pub. No. 27394r1 Rev. 4/2019

WATTSTOPPER | DIGITAL LIGHTING MANAGEMENT | NETWORK COMPONENTS

WIRED NETWORK BRIDGE | LMBC-300

NOTE: A new wireless version of the DLM network bridge is now available (model LMBC-650). Make your next installation faster, easier, and more flexible with DLM wireless networking!

Provides connectivity between a DLM local network and a BACnet-compatible DLM segment network

Supports third party integration with BAS through BACnet MS/TP

Optional wiring harness for fast installation of multiple devices in close proximity

MS/TP BACnet automatic configuration for DLM segment network eliminates the need for DIP switches

Class 2 device powered from DLM local network

Plug n˙ Go™ automatically connects module with all devices on DLM local network

BACnet
Registered trademark of ASHRAE

Description

The LMBC-300 Digital Network Bridge provides a segment network connection for a group of Digital Lighting Management (DLM) local network devices. This enables individual DLM local networks to be aggregated into a larger system, which, in turn, can be remotely managed from a DLM Segment Manager or a building automation system (BAS).

Operation

An LMBC-300 operates on Class 2 power supplied to a DLM local network by one or more DLM room controllers. It is connected to the free-topology local network at any convenient location using a standard LMRJ cable, and has terminals for connection to the segment network using LM-MSTP wire. The LMBC-300 monitors the DLM local network and automatically exposes all room devices, settings and calibrations through the segment network. Incorporating a Network Bridge in each DLM local network also allows the individual local networks to respond in concert to schedules created and broadcast from a DLM Segment Manager.

Local Network to Segment Network Link

The LMBC-300 Network Bridge provides a two-way communication link between local network devices and a DLM Segment Manager or third party building automation system. The LMBC-300 makes all local device settings visible and adjustable through the LMCS-100 DLM software. This includes settings previously made locally either by Plug n˙ Go, Push n˙ Learn, an LMCT-100 configuration tool or the LMCS-100 DLM software. Additionally, many DLM device settings are made available to any BAS system that uses the BACnet protocol.

Applications

The LMBC-300 is ideal for projects that require centralized monitoring, control or configuration. It enables communication between DLM devices on the local network and front end hardware. This facilitates advanced sequences of operation including load shedding, communication with other BACnet based systesm, and the ability to update firmware in any DLM device via the LMCS for a single location. An LMBC-300 is required for each local network in order to connect to an LMSM Segment Manager.

Features

- Component of Digital Lighting Management integrated control systems
- Adds segment network functionality a to DLM local network
- Communicates all DLM local network data and device settings to a Segment Manager and/or LMCS software
- Easy integration with BAS through use of standard BACnet objects to represent DLM local network device settings and states
- Class 2 operation and plenum rated housing facilitate simple installation
- DIN rail mounting clamp provided with the unit to facilitate box or panel mounting
- UL 2043 plenum rated
- This product meets the materials restrictions of RoHS
- BAA/TAA-compliant models available

PROJECT		LOCATION/ TYPE	

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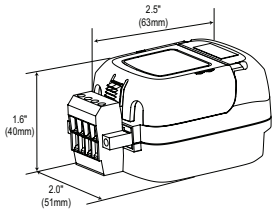
Specifications

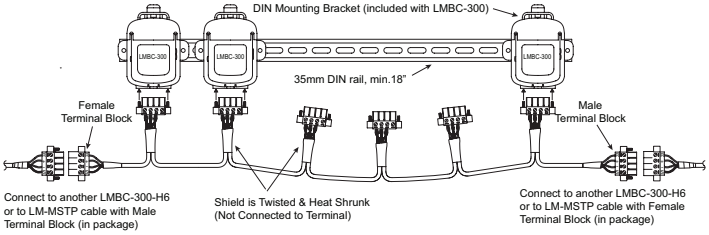
- Operating voltage: 24VDC from DLM local network
- Current consumption: 30mA
- DLM local network connection: 2 RJ45 ports
- Removable terminal block for twisted pair DLM segment network connection
- Segment network parameters:
  - Wattstopper LM-MSTP wire rated for BACnet MS/TP (RS485)
  - Linear topology; 4000' maximum per segment
  - Up to 40 local networks, or up to 300 DLM devices
- DIN rail mounting plate provided with the unit for cabinet or panel mounting
- Status LEDs indicate normal operation
- Operating conditions: for indoor use only; 32-158°F (0-70°C); 0-95% RH, non-condensing
- UL and cUL listed (E101196)
- FCC part 15 compliant
- Five year warranty

Dimensions, Mounting & Optional Wiring Harness

Product Dimensions



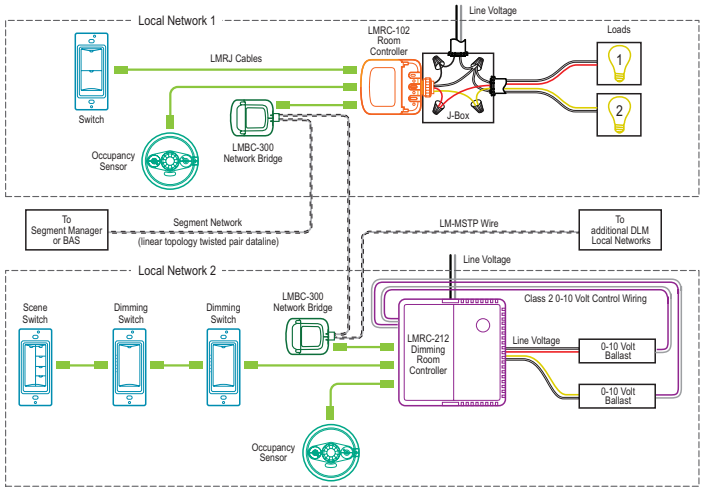
DIN Rail Mounting and Wiring using LMBC-300-H6 Wiring Harness



Typical Connections to DLM Local Networks and Segment Network Dataline

Wattstopper LM-MSTP wire must be used for the Segment Network. LMBC-300 wiring terminations should be made using ferrules sized for 20 AWG conductors.

Plug DLM local network components together in any configuration using Cat 5e cables with RJ45 connectors.



Ordering Information

Catalog #		Description
☐	LMBC-300	Wired Network Bridge
☐	LMBC-300-U	Wired Network Bridge, BAA/TAA compliant*
☐	LMBC-300-H6	Wiring harness with connectors for 6 Wired Network Bridges (ordered separately)
☐	LMBC-650	Wireless Network Bridge

*Product is compliant with Buy American Act and Trade Agreements Act

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Pub. No. 27126r1 Rev. 10/2019

WATTSTOPPER®

DIGITAL LIGHTING MANAGEMENT | LOAD CONTROLLERS

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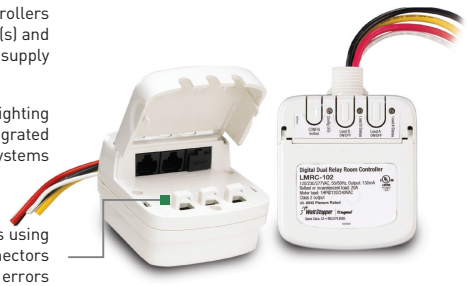
ON/OFF ROOM CONTROLLERS | LMRC-100 SERIES

Plenum-rated controllers with line voltage relay(s) and switching power supply

Components of Digital Lighting Management integrated control systems

Plug to other components using Cat 5e cables with RJ45 connectors eliminating wiring errors



Plug n˙ Go automatic configuration for maximum energy efficiency

Support energy saving manual-on and bi-level lighting control strategies

Description

LMRC-100 Series Digital Room Controllers include one or two relay(s) for on/off control of a total of 20 amps, and a high-efficiency switching power supply. They are the foundation of a Wattstopper Digital Lighting Management (DLM) system, and allow integration of occupancy sensors, daylighting sensors and switches for energy-efficient lighting control.

Operation

LMRC-100 Series Room Controllers operate on one, single phase 120/230/240/277 volt, 20 amp, feed and provide Class 2 power to sensors and switches via the DLM local network. Once powered up, Plug n˙ Go automatically configures system components for the most energy-efficient operation. The room controllers then switch lighting or motor loads on and off in response to input from the communicating devices. The DLM system may be reconfigured using Push n˙ Learn without the need for tools or a PC. Additionally, the LMCT-100-2 wireless configuration tool can be used for load configuration.

Plug n˙ Go Automatic Configuration

DLM room controllers manage Plug n˙ Go automatic system configuration, which establishes functionality based on the installed components. When room controllers are connected only to occupancy sensors, the system defaults to automatic on/off operation. If a wall switch is added to a system with one load, the load defaults to manual-on/automatic-off operation. If there is a wall switch and multiple loads, load one turns on automatically, while additional loads default to manual-on control; all loads turn off automatically.

Applications

LMRC-100 Series Room Controllers are ideal for single or multiple zone on/off lighting control applications. The LMRC-101 helps specifiers comply with basic On/Off requirements, while the LMRC-102 is designed for bi-level switching. Both controllers are appropriate for applications in private offices, open offices, conference rooms, lunch rooms and break rooms in any commercial building.

Features

- Plug n˙ Go™ automatic configuration for quick installation and maximum energy savings
- Push n˙ Learn™ functionality for personalization without the need for tools or a PC
- Digital Lighting Management components plug together on a free-topology Cat 5e DLM local network
- On/Off button for each load
- LED indicates status of connected load
- 3 RJ45 ports with integral strain relief and hinged dust cover
- Zero-crossing circuitry for each relay for reliability and increased product life
- Attach to standard electrical box through ½˝ knockout; UL (2043) plenum rated
- The product meets the materials restrictions of RoHS
- BAA/TAA-compliant models available

PROJECT		LOCATION/ TYPE	

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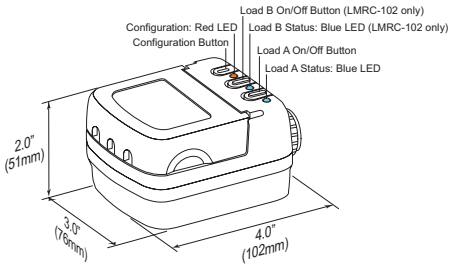
Specifications

- Input/output voltage: Single Phase 120/230/240/277VAC; 50/60Hz
- Maximum 20A combined load per Room Controller; each relay rated for:
  - Ballast or incandescent: 20A
  - E-ballast: 16A @ 120/277VAC (per NEMA 410)
  - Motor load: 1Hp
- Class 2 output to DLM local network: 24VDC, 150mA across 3 RJ45 ports
- Operating conditions: for indoor use only; 32-104°F (0-40°C); 5-95% RH, non-condensing
- DLM local network parameters with only LMPB-100, LMPL-101 and/or LMRC-100 Series Room Controllers:
  - Maximum of 4 total -10x Series Load Controllers
  - Maximum current: 600mA
  - Cat 5e cable: 150' per device to 1,000' max.
  - Up to 24 communicating devices
- UL (E101196) and cUL listed
- UL (2043) plenum rated
- FCC part 15 compliant
- Five-year warranty

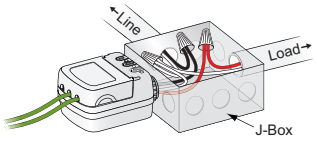
Controls & Mounting

Controls and Dimensions

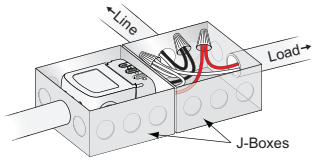


LMRC-100 Series Room Controllers include a 1/2" (12.7mm) threaded nipple and locking ring.

Mounting and Wiring



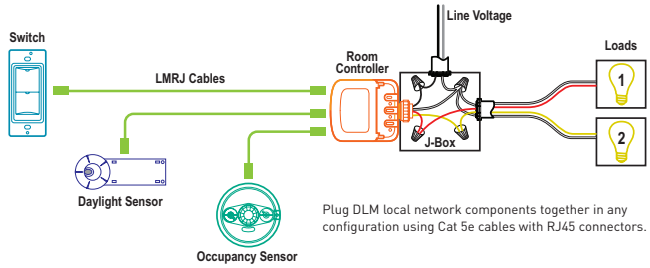
Mounting outside a j-box (plenum space). Two LMRC Room Controllers may be mounted to the j-box.



Mounting inside a j-box. Low voltage wiring is run to the LMRC Room Controller in conduit.

Connecting

Sample Connection Diagram for Bi-Level Control Using LMRC-102



Plug DLM local network components together in any configuration using Cat 5e cables with RJ45 connectors.

Ordering Information

Catalog #		Description	Total Load Rating (any/all relays)				Class 2 Output
			Single Phase Voltage 50/60Hz	Incandescent	Ballast	Motor	
☐	LMRC-101	Single Relay Room Controller	120/230/240/277VAC	20A	20A	1 Hp	24VDC 150mA
☐	LMRC-102	Dual Relay Room Controller					
☐	LMRC-102-U	Dual Relay Room Controller BAA/TAA compliant*					
☐	LMCT-100-2	Digital Wireless Configuration Tool					

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Pub. No. 27318r1 5/2019

WATTSTOPPER®

DIGITAL LIGHTING MANAGEMENT | LOAD CONTROLLERS

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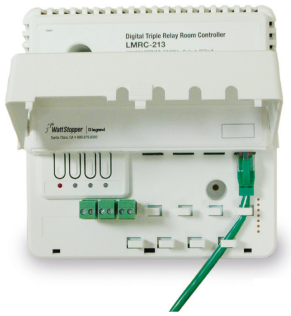
ON/OFF/0-10 VOLT DIMMING ROOM CONTROLLERS | LMRC-210 SERIES

Plenum-rated controllers with line voltage relay(s) and 0-10 volt dimming output(s)

120/230/240/277 volt and 347 volt models

Plug to other components using Cat 5e cables with RJ45 connectors eliminating wiring errors



Plug n' Go automatic configuration for maximum energy efficiency

Store load preset level and 16 scene preset levels for each load

Support energy saving manual-on, bi-level, tri-level and dimming control strategies

Description

LMRC-210 Series Digital Room Controllers include one, two or three relay(s) to switch a total of 15 or 20 amps, a high-efficiency switching power supply and one 0-10 volt output per relay for control of dimmable loads including electronic ballasts (Advance Mark 7, or equivalent). They are the foundation of a Wattstopper Digital Lighting Management (DLM) system, and allow integration of occupancy sensors, daylighting controls and switches for energy-efficient lighting control.

Operation

LMRC-210 Series Room Controllers operate on one 120, 230, 240, or 277 volt, 20 amp, or 347 volt, 15 amp, feed and provide Class 2 power to sensors and switches via the DLM local network. Once powered up, Plug n' Go automatically configures system components for the most energy-efficient operation. The room controllers then dim or switch lighting or motor loads in response to input from the communicating devices. When a dimming input is received, the relay switches on when the dimmed level rises above zero, and off when it reaches zero, to coordinate control of power and the 0-10 volt signal to the load. They also monitor the current draw of the total connected load. Each room controller stores up to 16 scene preset levels for each dimmed output. Additionally, the LMCT-100-2 wireless configuration tool can be used for load configuration.

Room controllers built starting Q3 of 2012 include circuity to open their 0-10V signal on loss of LMRC's power, so any separately powered ballast or driver connected to those 0-10V wires will go to full brightness.

Plug n' Go Automatic Configuration

DLM room controllers manage Plug n' Go automatic system configuration, which establishes functionality based on the installed components. When room controllers are connected only to occupancy sensors, the system defaults to automatic on/off operation. If a wall switch is added to a system with one load, the load defaults to manual-on/automatic-off operation. If there is a wall switch and multiple loads, load one turns on automatically, while additional loads default to manual-on control; all loads turn off automatically. At system startup, default dimming parameters are established including: levels for scene presets 1-4; fade times; and fade and ramp rates. Dimming and system parameters may be customized using Push n' Learn.

Applications

LMRC-210 Series Room Controllers are ideal for single or multiple zone on/off or dimming lighting control applications. They are appropriate for applications in private offices, open offices, conference rooms and classrooms in any commercial building. LMRC-210 Series Room Controllers also help facility managers who want to track building power usage by monitoring current for lighting or other loads. A network bridge (LMBC-300) is required to expose DLM local network power data readings to a Segment Manager or BAS.

PROJECT		LOCATION/ TYPE	

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Features

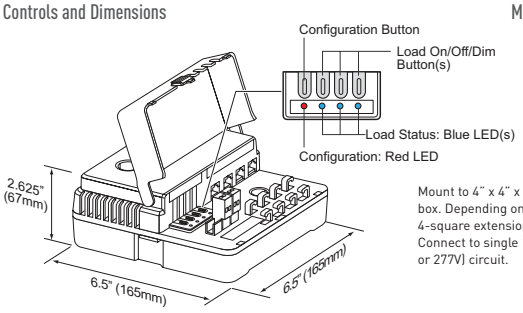
- Plug n˙ Go™ automatic configuration for quick installation and maximum energy savings
- Push n˙ Learn™ functionality for personalization without the need for tools or a PC
- Digital Lighting Management components plug together on a free-topology Cat 5e DLM local network
- On/Off/Dim local override button for each load
- LED indicates status of each load
- 0-10V signal opens on loss of LMRC power
- Integral current monitoring of total connected load
- Optional lamp burn in; 12 or 100 hours
- 4 RJ45 ports with integral strain relief
- Zero-crossing circuitry for each relay for reliability and increased product life
- UL 2043 plenum rated
- The product meets the materials restrictions of RoHS
- BAA/TAA-compliant models available

Specifications

- Voltage: Single Phase 120/230/240/277VAC or 347VAC; 50/60Hz
- Maximum 20A combined load per Room Controller; each relay rated for: @ 120/277V, 20A ballast or incandescent, 16A E-ballast (per NEMA410),or 1Hp motor load; @ 347V, 15A ballast only
- Class 2 dimming control signal: 0-10VDC, sinks up to 100mA per channel for control of compatible ballasts (50 if each sources 2mA)
- Class 2 output to DLM local network: 24VDC, up to 250mA across 4 RJ45 ports
- Operating conditions: for indoor use only; @ 120/277V: 32-158°F (0-70°C), @ 347V 32-140°F (0-60°C); 5-95% RH, non-condensing
- DLM local network parameters:
  - Maximum current: 800mA
  - Category 5e cable: 150˙ per device to 1,000˙ max.
  - Up to 64 loads
  - Up to 48 communicating devices
  - Maximum 4 LMPB-100, LMPL-101 or LMRC-100 Series Room Controllers
- UL (E101196) and cUL listed
- FCC part 15 compliant
- Five year warranty

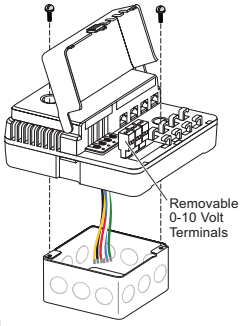
Controls & Mounting

Controls and Dimensions



Mount to 4" x 4" x 2 1/8" deep electrical box. Depending on outputs used, a 4-square extension box may be needed. Connect to single 15A (347V) or 20A (120 or 277V) circuit.

Mounting and Wiring



Load Parameter (for each dimmed output)	Default Setting	Available Options
High trim	100%	1-100%
Low trim	0%	0-99%
Preset level: Scenes 1-16	1: 100%, 2: 75%, 3: 50%, 4: 25%, 5-16: 100%	all: 0-100%
Preset fade time	2 seconds	0 seconds -18 hours
Lamp burn in time	0	0, 12 or 100 hours

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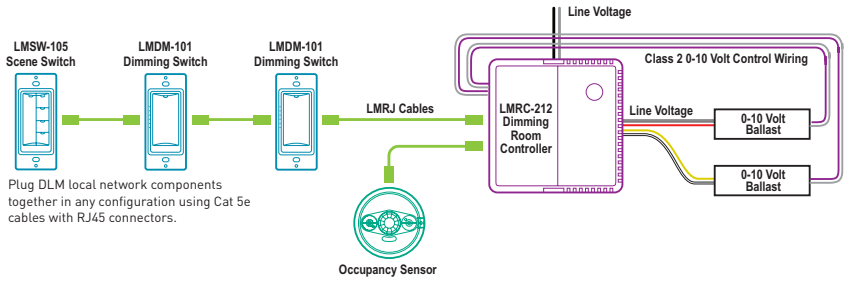
Connecting

Sample Connection Diagram with Dimming Switches and Scene Control



Plug DLM local network components together in any configuration using Cat 5e cables with RJ45 connectors.

Ordering Information

Catalog #	Description	Single Phase Voltage 50/60Hz	Total Load Rating (any/all relays)			Class 2 Outputs
			Ballast	Incan	Motor	
☐ LMRC-211	1 Relay Room Controller, 0-10V dimming	120/230/240/277VAC	20A	20A	1 Hp	24VDC, 250mA and 0-10VDC
☐ LMRC-211-U	1 Relay Room Controller, 0-10V dimming, BAA/TAA compliant*					
☐ LMRC-211-347	1 Relay Room Controller, 0-10V dimming	347VAC only	15A	-	-	
☐ LMRC-212	2 Relay Room Controller, 0-10V dimming	120/230/240/277VAC	20A	20A	1 Hp	
☐ LMRC-212-U	2 Relay Room Controller, 0-10V dimming, BAA/TAA compliant*					
☐ LMRC-212-347	2 Relay Room Controller, 0-10V dimming	347VAC only	15A	-	-	
☐ LMRC-213	3 Relay Room Controller, 0-10V dimming	120/230/240/277VAC	20A	20A	1 Hp	
☐ LMRC-213-U	3 Relay Room Controller, 0-10V dimming, BAA/TAA compliant*					
☐ LMRC-213-347	3 Relay Room Controller, 0-10V dimming	347VAC only	15A	-	-	
☐ LMCT-100-2	Digital Wireless Configuration Tool					
☐ LMRC-CA	Conduit Adapter for Low Voltage Connections					

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DIGITAL LIGHTING MANAGEMENT | LOAD CONTROLLERS

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FORWARD PHASE DIMMING ROOM CONTROLLERS | LMRC-220 SERIES

Versatile 20A controllers with line voltage relay(s) and triac-based forward phase control dimming

Compatible with most load types; three selectable dimming curves for each load

Plug to other components using Cat 5e cables with RJ45 connectors eliminating wiring errors

Plug n' Go automatic configuration for quick startup

Store load preset level and 16 scene preset levels for each load

Facilitate energy saving dimming control strategies including automatic daylight harvesting

RoHS

Description

LMRC-220 Series Digital Room Controllers include one or two output(s) to control a total of up to 20 amps for certain load types. Load ratings include incandescent, magnetic low voltage, forward phase compatible electronic low voltage and LED drivers, neon and cold cathode, and dimmable two-wire and three-wire fluorescent ballasts, and E-ballasts. They are the foundation of a Wattstopper Digital Lighting Management (DLM) system, and allow integration of occupancy sensors, daylighting controls and switches for energy-efficient lighting control.

Operation

LMRC-220 Series Room Controllers operate on one 120 or 277 volt, 20 amp, feed and provide Class 2 power to sensors and switches via the DLM local network. If two outputs, they should control the same load type and each is capable of dimming up to the full 20 amp rating of the device. Once powered up, Plug n' Go automatically configures system components for the most energy-efficient operation based on the installed components. The room controllers then dim or switch lighting in response to input from the communicating devices. They also monitor the current draw of the total connected load. Each room controller stores up to 16 scene preset levels for each dimmed output. Additionally, the LMCT-100-2 wireless configuration tool can be used for load configuration.

Plug n' Go and Push n' Learn Configuration

At system startup, default dimming parameters are automatically established including: levels for scene presets 1-4; fade times; and fade and ramp rates. The default square law dimming curve for each output can be changed to one of two fluorescent/LED curves using a button on the room controller. An On/Off/Dim load override button is available to test each load. Dimming and system parameters may be customized from a wireless handheld configuration tool and using Push n' Learn. Customizable parameters include a low level trim to prevent loads from flickering at low levels, and a high level trim and a load preset level to save energy and increase lamp life.

Applications

LMRC-220 Series Room Controllers are ideal for manual or automatic lighting control, including daylight harvesting. They are appropriate for applications in conference and training rooms, classrooms, lecture halls, executive offices, restaurants and galleries. LMRC-220 Series Room Controllers also help facility managers who want to track building power usage by monitoring current in real time. A network bridge (LMBC-300) is required to expose DLM local network power data readings to a Segment Manager or BAS.

Features

- Plug n' Go™ automatic configuration for quick installation and maximum energy savings
- Push n' Learn™ functionality for personalization without the need for tools or a PC
- Digital Lighting Management components plug together on free-topology Cat 5e DLM local network
- On/Off/Dim local override button for each load
- LED indicates status of each load
- Integral current monitoring of total connected load
- Optional lamp burn in; 12 or 100 hours
- Square law, 2-wire and 3-wire fluorescent/LED curves
- 4 RJ45 ports with integral strain relief
- Zero-crossing circuitry for each relay for reliability and increased product life
- UL 2043 plenum rated
- The product meets the materials restrictions of RoHS

PROJECT		LOCATION/ TYPE	

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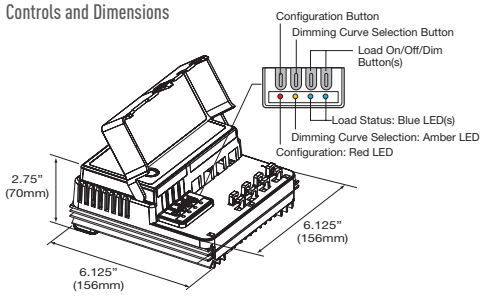
Specifications

- Input/ouput voltage: 120/277VAC, 50/60Hz
- Maximum 20A combined load per Room Controller; each output individually rated for:
  - 20A: tungsten, MLV, ELV or LED (forward phase compatible transformers or drivers)
  - 16A: 2-wire fluorescent or neon/cold cathode (electronic or magnetic dimming ballast), 3-wire fluorescent (electronic dimming ballast), or E-ballast
- Minimum load: 10W
- Class 2 output to DLM local network: 24VDC, up to 250mA across 4 RJ45 ports
- DLM local network parameters:
  - Maximum current: 800mA
  - Cat 5e cable: 150' per device up to 1,000' max.
  - Up to 64 loads
  - Up to 48 communicating devices
  - Maximum 4 LMPB-100, LMPL-101 or LMRC-100 Series Room Controllers
- Operating conditions: for indoor use only; 32-131°F (0-55°C); 5-95% RH, non-condensing
- UL and cUL listed
- FCC part 15 compliant
- Five year warranty

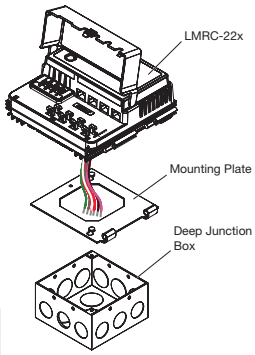
Controls & Mounting

Controls and Dimensions



Mounting and Wiring

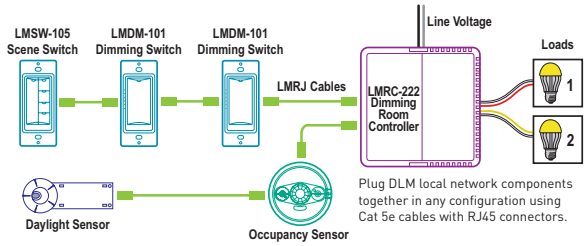
Mount to 4" x 4" x 2 1/8" deep electrical box. Depending on outputs used, a 4-square extension box may be needed. Connect to single 16A or 20A circuit (see specifications above).



Load Parameter (for each dimmed output)	Default Setting	Available Options
High trim	100%	1-100%
Low trim	0%	0-99%
Preset level: Scenes 1-16	1: 100%, 2: 75%, 3: 50%, 4: 25%, 5-16: 100%	all: 0-100%
Preset fade time	2 seconds	0 seconds -18 hours
Lamp burn in time	0	0, 12 or 100 hours

Connecting

Sample Connection Diagram with Dimming Switches and Scene Control



Plug DLM local network components together in any configuration using Cat 5e cables with RJ45 connectors.

Wire Color	Function
Black	Line in
White	Neutral
Green	Ground
Red	Load A dimmed hot
Red/ black	Load A switched hot*
Yellow	Load B dimmed hot
Yellow/black	Load B switched hot*

* for 3-wire dimming applications

Ordering Information

Catalog #	Description	Voltage	Total Load Rating	Class 2 Output
☐ LMRC-221	1 Load Forward Phase Dimming Room Controller	120/277 VAC, 50/60Hz	16A or 20A (see details above)	24 VDC, 250mA
☐ LMRC-222	2 Load Forward Phase Dimming Room Controller			
☐ LMCT-100-2	Digital Wireless Configuration Tool			
☐ LMRC-CA2	Hinged Conduit Adapter for Low Voltage Connections			

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Section 23 09 23.33

VIBRATION INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes vibration switches and combination switch and transmitters connected to direct digital control systems for HVAC.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.33.

1.3 DEFINITIONS

A. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating default control signal with loss of power, calibration data specific to each unique application, and electrical power requirements.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.

2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring and cable.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: To include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 MECHANICAL VIBRATION SWITCHES

A. Description: Inertia-sensitive armature mechanism trips on high vibration and operates snap action switch.

B. Performance:

1. Frequency Range: Zero to 3600 rpm.
2. Vibration Range: Zero to 10 g.
3. Temperature Limits: Minus 40 to 158 deg F.
4. Electrical Rating: 15 A at 125- or 480-V ac.
5. Switch Type: DPDT snap switch.
6. Start Delay: 20 to 30 seconds, by applying reset voltage at start signal to prevent switch from tripping.

C. Operator Interface:

1. Vibration Set-Point Adjustment: Zero to 100 percent of range.
2. Push-button reset on switch face and reset coil for remote reset.

D. Enclosure Construction:

1. Cast aluminum.
2. NEMA 250, Type 4X.
3. Electrical Connection: Screw terminals.
4. Conduit Connection: 3/4-inch trade size.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 VIBRATION INSTRUMENT APPLICATIONS

A. General: Mechanical switch.

3.3 INSTALLATION

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

C. Properly support instrument wiring and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to 20lbs of force.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Switches: Calibrate switches to make or break contact at set points indicated.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

End of Section

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Section 23 09 23.43

WEATHER STATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes weather stations connected to direct-digital controls for HVAC.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.43.

1.3 DEFINITIONS

A. I/O: Input/output.

B. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

C. RS-485: A TIA standard for multipoint communications using two twisted pairs.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating control signal over range, electrical power requirements, and limitations of ambient operating environment including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For weather stations to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 WEATHER STATION

A. Description:

1. Weather station shall measure and record wind speed and direction, air temperature and relative humidity, barometric pressure, solar radiation, and rain.
2. Design weather station for applications with minimal visual impact, high reliability, and a long interval between routine servicing.
3. Weather station shall use solid-state sensors with no moving parts.
4. Weather station shall not be impaired by heavy snowfall or freezing conditions that produce rime ice. Provide a thermostatically controlled heater element in the sensor head that keeps the wind sensor elements and the precipitation sensor surface free of snow and ice to minus 62 deg F.
5. Weather station shall directly connect to host device, or wirelessly connect to a host device through a fully integrated, industrial-grade, 916-MHz spread spectrum radio-frequency communications technology. Where required by application, replace 916-MHz radio-frequency components with 922-MHz and 2.4-GHz radio-frequency components to comply with local, regional, and national radio-frequency licensing requirements.
6. RS-232 serial data I/O shall be located on the bottom of the weather station and used as a second serial communications port, for programming and testing the system, or for direct data downloads using a personal computer or personal digital assistant.
7. Weather station shall be provided with a mounting system supplied by weather station manufacturer that is suitable for the installation.

B. Sensor Technology:

1. Wind speed and direction shall use acoustic techniques. Sensor shall consist of three equally spaced ultrasonic transducers in a horizontal plane. Values of any two array paths shall enable computation of both wind speed and direction, and a signal processing technique shall enable the measurement to be calculated using the two array paths of the best quality.
2. Rain shall be measured using a stainless-steel piezometric impact surface that counts the raindrops and measures their acoustic signature, integrating that information to provide a near-real-time value for rainfall amount and rate.
3. Barometric pressure, relative humidity, air temperature, and solar radiation measurements shall be made by scientific grade sensors.
4. Air-temperature and relative-humidity sensors shall be combined in an integrated, user-replaceable unit that requires no calibration.

    a. Relative humidity sensor shall be a thin-polymer, capacitive sensor.
    b. Air-temperature sensor shall be a capacitive ceramic sensor.

5. Barometric pressure shall be measured with a capacitive silicon, temperature-corrected, strain gage.
6. Solar radiation shall be measured by a silicon pyranometer with a cut filter limiting the spectral exposure to the 300- to 1100-nm wavelength.

C. Performance:

1. Air Temperature:

    a. Range: Minus 60 to 140 deg F.
    b. Accuracy: Within 0.9 deg F.
    c. Resolution: 0.1 deg F.

2. Relative Humidity:

    a. Range: Zero to 100 percent.
    b. Accuracy: Within 3 percent over the range of zero to 90 percent and within 5 percent between 90 to 100 percent.
    c. Resolution: 0.1 percent.

3. Barometric Pressure:

    a. Range: 17.72- to 32.48-in. Hg.
    b. Accuracy: 0.015-in. Hg between 32 to 86 deg F.
    c. Resolution: 0.03-in. Hg between minus 60 to 140 deg F.

4. Solar Radiation:

    a. Spectral Range: 300 to 1100 nm.
    b. Reproducibility: Within 2 percent.
    c. Output: 0.2 mV per watts per square meters.
    d. Range: Zero to 1000 W per square meters.
    e. Temperature Range: Minus 40 to 130 deg F.

5. Rain:

a. Collecting Area: 9.3 sq. in..
b. Range: Zero to 7.87 inches per hour.
c. Accuracy: Within 5 percent.
d. Resolution: 0.001 inch.

6. Wind Direction:

a. Azimuth: Zero to 360 degrees.
b. Response Time: 250 ms.
c. Accuracy: Within 2 degrees.
d. Resolution: 1 degree.

7. Wind Speed:

a. Range: Zero to 134 mph.
b. Response Time: 0.25 second.
c. Accuracy: Greater of 0.67 mph or 2 percent.
d. Resolution: 0.22 mph.

8. Data Storage: 60 days of hourly data.

D. Output Signals:

1. RS-232 or RS-485 serial interface directly from weather station to host.
2. In applications that cannot accept a serial signal, provide a serial-to-analog converter.
3. Serial-to-Analog Converter:

a. Serial converter designed to add analog outputs for measuring instruments that have only serial output.
b. Configure to give analog outputs from all measuring sensors and calculated parameters.
c. Each converter shall have four analog outputs with a 4- to 20-mA signal.
d. Provide multiple converters for applications requiring more points.
e. Converter requires a 24-V dc power supply.

E. Communication Interface:

1. Weatherproof serial cables shall be used to connect the RS-232 I/O on the weather station. Cables shall use nickel-plated brass DB-9 connectors for corrosion resistance and include a Sanoprene jacket suitable for both high-ultraviolet and direct-burial environments.
2. An RF4xx spread spectrum radio-frequency transceiver shall be provided with every wireless weather station.

F. Unit shall be provided with a 120-V ac, 60-Hz power supply, a serial cable, and an antenna.

G. Software:

1. Data Transfer Protocols, Software, and Data Interface Hardware: Weather stations that communicate using a proprietary protocol shall be provided with a

software development kit to enable a qualified software developer in development of software drivers for third-party devices or software.

2. Manufacturer shall submit description and pricing information of software application offerings for weather station management, data acquisition and logging, report generation, and data display for review and consideration.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support weather station, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to forces that are consistent with building code structural design requirements.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where components are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.5 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each weather station installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment used for calibrating. Submit procedures before calibration and adjustment.
3. For each analog signal, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed weather stations shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed weather station with a signal accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each weather station according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

3.8 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of systems and equipment Installer. Include semiannual preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain weather stations.

B. Provide a complete set of instructional videos covering each product specified and installed and showing the following:

1. Software programming.
2. Calibration and test procedures.
3. Operation and maintenance requirements and procedures.
4. Troubleshooting procedures.

C. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

D. Record videos on DVD disks.

E. Owner shall have right to make additional copies of video for internal use without paying royalties.

End of Section

Section 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Joining materials.
4. Transition fittings.
5. Dielectric fittings.
6. Bypass chemical feeder.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pipe.
2. Fittings.
3. Joining materials.
4. Bypass chemical feeder.

B. LEED Submittals:
1. Provide manufacturers' or third-party certification of testing to and compliance with the California Department of Public Health (CDPH) Standard method v1.2-2017, that includes the following information:
   - The exposure scenario used to determine compliance.
   - The range of total VOCs after 14 days, measured as specified in the CDPH Standard Method v1.2:
     - 0.5 mg/m^3 or less;
     - Between 0.5 and 5.0 mg/m^3; or
     - 5.0 mg/m^3 or more
   - Laboratory accreditation under ISO/IEC 17025.
   - Claims of compliance for wet-applied products must state the amount applied in mass per surface area
2. Provide MSDS or other manufacturer documentation with disclosure of VOC content for all wet-applied products.

3. Complete "LEED Materials Documentation Sheet" with IEQc2 information for adhesives/sealants installed within the waterproofing membrane.

4. Product Data: For adhesives, indicating VOC content.
5. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
6. Product Data: For coatings, indicating VOC content.
7. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.
8. Product Data: For sealants, indicating VOC content.
   Laboratory Test Reports:

C. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

E. Preconstruction Test Reports:

1. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:
1. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.6 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on water quality.

1.7 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 100 psig at 200 deg F.
2. Chilled-Water Piping: 150 psig at 73 deg F.
3. Condenser-Water Piping: 150 psig at 73 deg F.
4. Glycol Cooling-Water Piping: 150 psig at 150 deg F.
5. Makeup-Water Piping: 80 psig at 150 deg F.
6. Condensate-Drain Piping: 150 deg F.
7. Blowdown-Drain Piping: 180 deg F.
8. Air-Vent Piping: 180 deg F.
9. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. T-DRILL Industries Inc.

E. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Elster Perfection Corporation.
b. Grinnell G-Fire by Johnson Controls Company.
c. Matco-Norca.
d. Precision Plumbing Products.
e. Victaulic Company.

2. Description:

a. Standard: IAPMO PS 66.
b. Electroplated steel nipple, complying with ASTM F 1545.
c. Pressure Rating: 300 psig at 225 deg F .
d. End Connections: Male threaded or grooved.
e. Lining: Inert and noncorrosive, propylene.

2.6 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

2.01 PIPE, FITTINGS AND JOINING MATERIALS

A. Chilled Water

Pipe Size	Pipe	Fittings	Joint
2.5-inch & below	ASTM B88 Type L Hard Cop-per	ASME B16.22 Wrought Copper	ASTM B32 Solder 95 Sn / 5 Sb 95.5 Sn / 4 Cu / 0.5 Ag
3-inch & above	ASTM A53 Sch 40 Black Steel	ASME B16.9 Wrought Steel	ASME B16.9 Butt weld

B. Process Chilled Water

Pipe Size	Pipe	Fittings	Joint
All sizes	ASTM B88 Type L Hard Cop-per	ASME B16.22 Wrought Copper	ASTM B32 Solder 95 Sn / 5 Sb 95.5 Sn / 4 Cu / 0.5 Ag
2-inch & below	ASTM B88 Type L Hard Cop-per	ASME B16.22 Wrought Copper	ASME B16.22 Solder

C. Heating Hot Water

Pipe Size	Pipe	Fittings	Joint
2.5-inch & below	ASTM B88 Type L Hard Cop-per	ASME B16.22 Wrought Copper	ASTM B32 Solder 95 Sn / 5 Sb 95.5 Sn / 4 Cu / 0.5 Ag
3-inch & above	ASTM A53 Sch 40 Black Steel	ASME B16.9 Wrought Steel	ASME B16.9 Butt weld
2-inch & below	ASTM B88 Type L Hard Cop-	ASME B16.22 Wrought Copper	ASME B16.22 Solder

	per		

D. Low Pressure Steam, 15 psig and below

Pipe Size	Pipe	Fittings	Joint
2-inch & below	ASTM A53 Sch 40 Black Steel	ASTM A126 ASME B16.4 Cast or Malleable Iron	ASME B16.4 Threaded
2.5-inch & above	ASTM A53 Sch 40 Black Steel	ASME B16.9 Wrought Steel	ASME B16.9 Butt weld

E. High Pressure Steam, Above 15 psig

Pipe Size	Pipe	Fittings	Joint
2-inch & below	ASTM A53 Sch 40 Black Steel	ASME B16.9 Wrought Steel	ASME B16.9 Butt weld
		ASME B16.11 Forged Steel	ASME B16.11 Socket Weld
2.5-inch & above	ASTM A53 Sch 40 Black Steel	ASME B16.9 Wrought Steel	ASME B16.9 Butt weld

F. Steam Condensate

Siz-es	Pipe	Fittings	Joint
2-inch & below	ASTM A53 Sch 80 Black Steel	ASTM A126 ASME B16.4 Cast or Malleable Iron	ASME B16.4 Threaded
2.5-inch & above	ASTM A53 Sch 80 Black Steel	ASME B16.9 Wrought Steel	ASME B16.9 Butt weld

G. Cooling Coil Condensate Drain

Siz-es	Pipe	Fittings	Joint
All sizes	ASTM B88 Type M Hard Copper	ASME B16.22 Wrought Copper	ASTM B32 95 Sn/5 Sb or 95.5 Sn / 4 Cu / 0.5 Ag Solder
Cooling Coil Con-	ASTM B88	ASME B16.3026	ASTM B32

densate Drain 1.25" and above:	Type M Hard Copper	Wrought Copper DWV Fittings	95 Sn/5 Sb or 95.5 Sn / 4 Cu / 0.5 Ag Solder

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to the following:

1. Section 230523 "Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric nipples.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for copper tubing steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Install hangers for fiberglass piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

G. Support horizontal piping within 12 inches of each fitting and coupling.

H. Support vertical runs of copper tubing and steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

I. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.

I. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

J. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

K. Plain-End Mechanical-Coupled Joints: Prepare, assemble, and test joints in accordance with manufacturer's written installation instructions.

L. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

M. Pressure-Sealed Joints: The use of propress is not allowed.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

End of Section

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Section 23 21 16

HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air-control devices.
3. Strainers.
4. Connectors.

B. Related Requirements:

1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
2. Section 230523 "General Duty Valves for HVAC Piping" for specification and installation requirements for globe valves common to most piping systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.7 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett; a Xylem brand.
    c. NIBCO INC.
    d. TACO Comfort Solutions, Inc.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett; a Xylem brand.
    c. NIBCO INC.
    d. TACO Comfort Solutions, Inc.

2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 deg F.

C. Diaphragm-Operated Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. AMTROL, Inc.

D. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.
3. Seat: Brass.
4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Low inlet-pressure check valve.
7. Valve Seat and Stem: Noncorrosive.
8. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
9.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. AMTROL, Inc.
    b. Apollo Flow Controls; Conbraco Industries, Inc.
    c. Armstrong Pumps, Inc.

d. Bell & Gossett; a Xylem brand.
e. TACO Comfort Solutions, Inc.

2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett; a Xylem brand.
d. TACO Comfort Solutions, Inc.

2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

C. Bladder-Type ASME Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett; a Xylem brand.
d. TACO Comfort Solutions, Inc.

2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

E. Coalescing-Type Air and Dirt Separators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett; a Xylem brand.

2. Tank: Fabricated steel tank; ASME constructed and stamped for 125-psig (862-kPa) working pressure and 270 deg F (130 deg C) maximum operating temperature.
3. Coalescing Medium: Copper.
4. Air Vent: Threaded to the top of the separator.
5. Inline Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; Class 150 flanged connections for NPS 2-1/2 (DN 65) and larger.
6. Blowdown Connection: Threaded to the bottom of the separator.
7. Size: Match system flow capacity.

F. Air Purgers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett; a Xylem brand.
    d. TACO Comfort Solutions, Inc.

2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig.
4. Maximum Operating Temperature: 250 deg F.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig.

B. Duplex Basket Strainers:

1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: **40**-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

4. CWP Rating: 125 psig.

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: [**40**] [**60**]-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

2.4 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

B. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install throttling-duty valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on

Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

D. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

E. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

F. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

G. Install duplex strainers on incoming chilled water lines.

End of Section

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Section 23 21 23

HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Separately coupled, horizontally mounted, in-line centrifugal pumps.
2. Separately coupled, base-mounted, end-suction centrifugal pumps.
3. Automatic condensate pump units.

1.3 DEFINITIONS

A. ECM: Electronically commutated motor.

B. EPDM: Ethylene propylene diene monomer.

C. EPR: Ethylene propylene rubber.

D. FKM: Fluoroelastomer polymer.

E. HI: Hydraulic Institute.

F. NBR: Nitrile rubber or Buna-N.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of pump.

1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
2. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.

3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For each pump.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates for pumps, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints.

C. Seismic Performance: Pumps shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3.

2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bell and Gossett

2. American-Marsh Pumps.
3. Armstrong Pumps, Inc.
4. Aurora Pump; Pentair Ltd.
5. Crane Pumps & Systems.
6. Flowserve Corporation.
7. Grundfos Pumps Corporation.
8. ITT Corporation.
9. Mepco, LLC.
10. PACO Pumps; Grundfos Pumps Corporation, USA.
11. Patterson Pump Company; a Gorman-Rupp company.
12. Peerless Pump Company.
13. TACO Comfort Solutions, Inc.
14. Thrush Co. Inc.

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

D. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange connections.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft Sleeve: Type 304 stainless steel.
4. Pump Stub Shaft: Type 304 stainless steel.
5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR rubber bellows and gasket. Include water slinger on shaft between motor and seal.
6. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.

E. Shaft Coupling: Rigid, axially-split spacer coupling to allow service of pump seal without disturbing pump or motor.

F. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure : Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Variable-speed motor.
6. Provide integral pump motor variable-speed controller.
7.

2.3 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bell & Gossett

2. American-Marsh Pumps.
3. Armstrong Pumps, Inc.
4. Aurora Pump; Pentair Ltd.
5. Buffalo Pumps, Inc.
6. Crane Pumps & Systems.
7. Flowserve Corporation.
8. ITT Corporation.
9. Mepco, LLC.
10. PACO Pumps; Grundfos Pumps Corporation, USA.
11. Peerless Pump Company.
12. Scot Pump; a division of Ardox Corporation.
13. TACO Comfort Solutions, Inc.

14. Thrush Co. Inc.

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump with flexible shaft coupling as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

D. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring realignment of pump and motor shaft.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Carbon steel, with copper-alloy shaft sleeve.
4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR bellows and gasket.
5. Seal, Packing Type: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

E. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor.

F. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

G. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

H. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Variable-speed motor.
6. Provide integral pump motor variable-speed controller.
7. .

2.4 AUTOMATIC CONDENSATE PUMP UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Beckett Corporation.
2. Crane Pumps & Systems.
3. Grundfos Pumps Corporation.
4. Hartell Pumps; Milton Roy.
5. Little Giant Pump Co.

B. Source Limitations: Obtain pump units from single source from single manufacturer.

C. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Collects and removes condensate from fan coil units, air handling units, condensing boilers, and similar components. Include factory- or field-installed check valve and 72-inch- minimum, electrical power cord with plug.

D. Condensate pumps shall be rated for all plenum installation applications.

2.5 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. **300-psig** pressure rating, cast-iron body and end cap, pump-inlet fitting.
3. Bronze 16-mesh wire startup and Type 304 stainless steel permanent strainers with 3/16-inch perforations and 51 percent open area.
4. Type 304 stainless steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

2.6 ELECTRONICALLY COMMUTATED MOTOR (ECM)

A. Provide pumps so they are specified or scheduled with ECM.

1. Synchronous, constant torque, ECM with permanent magnet rotor. Rotor magnets to be time-stable, nontoxic ceramic magnets (Sr-Fe).
2. Driven by a frequency converter with an integrated power factor correction filter. Conventional induction motors will not be acceptable.
3. Each motor with an integrated variable-frequency drive, tested as one unit by manufacturer.
4. Motor speed adjustable over full range from 0 rpm to maximum scheduled speed.
5. Variable motor speed to be controlled by a 0- to 10 V-dc or 4- to 20-mA input.
6. Integrated motor protection verified by UL to protect the pump against over-/undervoltage, overtemperature of motor and/or electronics, overcurrent, locked rotor, and dry run (no-load condition).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

E. Equipment Mounting:

1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

F. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and spring hangers of size required to support weight of in-line pumps.

1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.

C. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

D. Comply with pump and coupling manufacturers' written instructions.

E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install check, shutoff, and throttling valves on discharge side of pumps.

F. Install suction diffuser and shutoff valve on suction side of pumps.

1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

I. Install check valve on each condensate pump unit discharge unless unit has a factory-installed check valve.

3.5 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping. Use startup strainer for initial startup.
4. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Hydronic pumps will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

End of Section

Section 23 22 13

STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes pipe and fittings for LP and HP steam and condensate piping:

1. Steel pipe and fittings.
2. Fiberglass pipe and fittings.
3. Joining materials.

B. Related Requirements:

1. Section 232216 "Steam and Condensate Heating Piping Specialties" for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Steel pipe and fitting.
2. Fiberglass pipe and fitting.
3. Joining material.

B. Sustainable Design Submittals:

1. Product Data: For adhesives and sealants, indicating VOC content.
2. Laboratory Test Reports: For adhesives and sealants, indicating compliance with requirements for low-emitting materials.
3. Environmental Product Declaration: For each product.
4. Health Product Declaration: For each product.
5. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.

C. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Fiberglass Pipe and Fitting Installers: Installers of fiberglass pipe and fittings shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Comply with ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. HP Steam Piping: **150 PSI**
2. Condensate Piping: 15 at **250 deg F**
3. Makeup-Water Piping: **80 psig 150 deg F**
4. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
5. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
6. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in piping applications articles.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.

E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

E. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

1. Verify fiberglass adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).
2. Verify adhesive complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

PART 3 - EXECUTION

3.1 HP STEAM PIPING APPLICATIONS

A. HP Steam Piping, NPS 2 and Smaller: Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. HP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. HP Steam Piping, NPS 14 through NPS 18: Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

D. HP Steam Piping, NPS 20 and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

E. Condensate piping above grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

F. Condensate piping above grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
2. RTRP and Glass-Fiber-Reinforced Thermosetting-Resin pipe with adhesive or flanged joints.

G. Condensate piping below grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
2. RTRP and Glass-Fiber-Reinforced Thermosetting-Resin pipe with adhesive or flanged joints.

H. Condensate piping below grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.2 ANCILLARY PIPING APPLICATIONS

A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

B. Vacuum-Breaker Piping: Outlet, same as service where installed.

C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to the following Sections or other Sections as needed:

1. Section 230523.11 "Globe Valves for HVAC Piping."
2. Section 230523.12 "Ball Valves for HVAC Piping."
3. Section 230523.13 "Butterfly Valves for HVAC Piping."
4. Section 230523.14 "Check Valves for HVAC Piping."
5. Section 230523.15 "Gate Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2

U. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

V. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

W. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet
2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4

X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Z. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 STEAM AND CONDENSATE PIPING SPECIALTIES INSTALLATION

A. Comply with requirements in Section 232216 "Steam and Condensate Heating Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic restraints in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for installation of hangers, supports, and anchor devices.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.

4. Spring hangers to support vertical runs.

D. Install hangers for steel steam supply piping and steel steam condensate piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Install hangers for fiberglass piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support horizontal piping within 12 inches of each fitting.

G. Support vertical runs of steel steam supply piping and steel steam condensate piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

H. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

F. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.8 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform the following tests and inspections:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

E. Prepare test and inspection reports.

End of Section

Section 23 22 16

STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following piping specialties for steam and condensate piping:

1. Strainers.
2. Stop-check valves.
3. Safety valves.
4. Steam traps.
5. Thermostatic air vents and vacuum breakers.
6. Flexible connectors.
7. Steam meters
8. Condensate meters.

B. Related Requirements:

1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
2. Section 230523 "General-duty Valves for HVAC Piping" for specification and installation requirements for valves for piping systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Strainer.
2. Flash tank.
3. Valve.
4. Steam trap.
5. Air vent and vacuum breaker.
6. Connector.
7. Meter.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

Steam Piping: 150 psig
1. Condensate Piping: 20 psig at 250 deg F .
2. Makeup-Water Piping: 150 psig at 73 deg F.
3. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
4. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
5. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: minimum 1/8" thick Type 316 Stainless-steel. For steam service: provide 3/64 mesh perforations with 20 mesh before steam traps and 100 mesh before control valves. For steam condensate service: provide mesh as follows:
   a. 0.057" openings for 1/2" through 2" NPS
   b. 0.124" openings for 2 1/2" though 4" NPS
   c. 0.250" openings for 5" NPS and larger
4. Tapped blowoff plug.

5. CWP Rating: 30 working steam pressure at 450 degrees F.

2.3 STEAM SAFETY VALVES

A. Cast-Iron Steam Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   a. Armstrong International, Inc.
   b. Kunkle Valve.
   c. Spirax Sarco, Inc.
2. Disc Material: Forged copper alloy with bronze nozzle.
3. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
4. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
7. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
8. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.4 STEAM TRAPS

A. Thermostatic Steam Traps:
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Armstrong International, Inc.
   b. Gestra MK 45-1.
2. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
3. Trap Type: Balanced pressure.
4. Bellows: Stainless steel or monel.
5. Head and Seat: Replaceable, hardened stainless steel.
6. Pressure Class: 150.

B. Float and Thermostatic Steam Traps:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong International, Inc.
   b. Gestra UNA 30 F&T.
2. Body and Bolted Cap: ASTM A126 cast iron.
3. End Connections: Threaded.
4. Float Mechanism: Replaceable, stainless steel.
5. Head and Seat: Hardened stainless steel.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel or monel.

8. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless-steel cage, valve, and seat.
10. Maximum Operating Pressure: 150 psig.

2.5 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong International, Inc.
   b. Barnes & Jones, Inc.
   c. Dunham-Bush, Inc.
   d. Hoffman Specialty.
   e. Spirax Sarco, Inc.
   f. Sterling.
   g. Tunstall Corporation.
2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Float, Valve, and Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
6. Pressure Rating: 300 psig
7. Maximum Temperature Rating: 350 deg F

B. Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong International, Inc.
   b. Dunham-Bush, Inc.
   c. Hoffman Specialty.
   d. Johnson Corporation (The).
   e. Spirax Sarco, Inc.
   f. Tunstall Corporation
2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
5. O-Ring Seal: Ethylene propylene rubber.
6. Pressure Rating: 300 psig .
7. Maximum Temperature Rating: 350 deg F

2.6 FLEXIBLE CONNECTORS

A. Stainless-Steel Bellows, Flexible Connectors:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Duraflex, Inc.
b. Flexicraft Industries.
c. Hyspan Precision Products, Inc.
d. Mason Industries, Inc.
e. Metraflex Company (The).
f. Twin City Hose, Inc.

2. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
3. End Connections: Threaded or flanged to match equipment connected.
4. Performance: Capable of 3/4-inchmisalignment.
5. CWP Rating: 150 psig
6. Maximum Operating Temperature: 250 deg F

2.7 CONDENSATE METERS

A. Meters shall be on the condensate return side and shall be sized and furnished by Cornell for installation by the Contractor.

B. 1-inch NPS pipe size, which handles flows from 3 – 70 gpm.

C. Meters will have eight digit local totaling displays (gallons) and a one pulse per gallon, 5 volt pulse output.

D. Output shall be tied to the building BACS.

E. Meters shall have internal line voltage power supply.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 PIPING INSTALLATION

A. Install piping to permit valve servicing.

B. Install drains, consisting of a tee fitting, NPS 3/4 full-port ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Install valves according to Section 230523. " General Duty Valves for HVAC Piping”

D. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment and elsewhere as indicated.

E. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full-port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

3.3 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.4 STEAM OR CONDENSATE METER INSTALLATION

A. Install meters with lengths of straight pipe upstream and downstream according to steam meter manufacturer's written instructions.

B. Provide data acquisition wiring. See Section 230923 "Direct Digital Control (DDC) System for HVAC"

3.5 SAFETY VALVE INSTALLATION

A. Install safety valves according to ASME B31.9, "Building Services Piping."

B. Pipe safety-valve discharge without valves to atmosphere outside the building.

C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps and control valves in accessible locations close to connected equipment.

B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

End of Section

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Section 23 22 23

STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes steam condensate pumps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated. Indicate pump's operating point on curves. Include receiver capacity and material.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 TWO-STAGE, CENTRIFUGAL PUMPS WITH FLOOR-MOUNTED RECEIVER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Armstrong Fluid Handling.
2. Bell & Gossett. / ITT Corporation.
3. Spirax Sarco Limited.

B. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pumps, controls, and accessories suitable for operation with steam condensate.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Configuration: Duplex floor-mounted pump with receiver and float switches; rated to pump 210 deg F steam condensate.

D. Receiver:

1. Floor mounted.
2. Close-grained cast iron.
3. (2) Externally adjustable 2-pole float switches
4. (2) Dial pressure gauges for pump discharge
5. (1) Water level gauge glass
6. (1) Dial thermometer
7. (2) Lifting eye bolts
8. (2) Bronze fitted, butterfly isolation valves (up to 75 gpm pump capacity) between pump suction and receiver
9. (1) Cast iron inlet strainer with vertical self-cleaning, bronze screen and large dirt pocket shall be mounted on the receiver. The screen shall be easily removable for cleaning, requiring no additional floor space for servicing.
10. Flanges for pump mounting.
11. Inlet vent and an overflow.

E. Pumps:
1. Mounted on receiver flange.
2. The water pumps shall be two-staged, centrifugal design, bronze fitted with enclosed cast bronze centrifugal impeller, permanently aligned and flanged mounted for vertical operation.
3. Each pump gpm shall be sized for 2 times the system return rate.
4. Each pump shall be close-coupled to a 3500 rpm, vertical, drip-proof motor and shall deliver its full capacity with condensate temperatures up to 210°F at sea level, at 2 ft. NPSH (net positive suction head).
5. Carbon/ceramic mechanical shaft seal shall be rated for 250°F.
6. Each pump shall include:
   a. Axial flow, first-stage dynamically balanced, cast bronze impeller
   b. Bronze straightening vanes
   c. Renewable bronze casing wear ring
   d. Stainless steel shaft
   e. Discharge gauge port tapping
   f. Drain tapping

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: Open, dripproof.
3. Enclosure Materials: Cast iron.

4. Motor Bearings: Permanently lubricated ball bearings.
5. Efficiency: Premium efficient.
6. NEMA Design: 250.

G. Control Panel:

1. Factory wired between pumps and float switches, for single external electrical connection.
2. Provide fused, control-power transformer if voltage exceeds 230 V ac.
3. NEMA 250, Type 1 enclosure with drip lip and piano hinged door and grounding lug, mounted on pump enclosing following:.
4. Motor controller for each pump.
5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
6. Manual lead-lag control to override electrical pump alternator and manually select the lead pump.
7. Momentary-contact "TEST" push button on cover for each pump.
8. Numbered terminal strip.
9. Disconnect switch.
10. The control panel shall be a mounted and wired NEMA 2 control cabinet with drip lip and piano hinged door enclosing the following:

    a. (2) Combination contactors with adjustable thermal overloads with fused disconnect and cover interlock for each motor
    b. (2) “Auto-Off-Hand” selector switch
    c. (1) Numbered terminal strip
    d. (2) Pump running pilot lights
    e. (1) Electrical alternator
    f. (1) Fused control circuit transformer when the motor voltage exceeds 230 Volts
    g. (1) Control power switching relay

11. The electrical alternator shall:
    a. Change the operating sequence automatically after each cycle.
    b. Provide simultaneous operation under peak load conditions.
    c. Operate the second pump automatically, should the active pump or its controls fail.
12. When a transformer is required, the control power will be supplied downstream of pump number one’s disconnect switch.
13. The control power switching relay shall allow the switch over of control power from pump number one to pump number two in the event of a failure or a no power condition of pump number one.

H. Capacities and Characteristics:
1. Refer to drawing schedule.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install pumps according to HI 1.1-1.2, HI 1.3, and HI 1.4. and in accordance with manufacturer's instructions

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so piping is not supported by pumps.

D. Install thermometers and pressure gages.

E. Power wiring, as required, shall be the responsibility of the electrical contractor. All wiring shall be performed per manufacturer's instructions and applicable state, federal, and local codes.

F. All factory wiring shall be numbered for easy identification and the numbers shall coincide with those shown on the wiring diagram.

G. All interconnecting wiring between the pump controls and control panel shall be enclosed in liquid tight flexible conduit.

H. The unit shall be factory tested as a complete unit and the unit manufacturer shall furnish elementary and connection wiring diagrams, piping diagrams, installation and operation instructions.

I. The unit shall be shipped completely assembled.

J. Certified test report shall be provided by the factory.

K. Equipment Mounting:

1. Install pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

B. Where installing piping adjacent to machine, allow space for service and maintenance.

C. Install a globe and check valve and pressure gage before inlet of each pump and a gate and check valve at pump outlet.

D. Pipe drain to nearest floor drain for overflow and drain piping connections.

E. Install full-size vent piping to outdoors, terminating in 180-degree elbow at point above highest steam system connection or as indicated.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Clean strainers.
3. Set steam condensate pump controls.
4. Set pump controls for automatic start, stop, and alarm operation.
5. Perform the following preventive maintenance operations and checks before starting:

    a. Set float switches to operate at proper levels.
    b. Set throttling valves on pump discharge for specified flow.
    c. Check motors for proper rotation.
    d. Test pump controls and demonstrate compliance with requirements.
    e. Replace damaged or malfunctioning pump controls and equipment.
    f. Verify that pump controls are correct for required application.

6. Start steam condensate pumps according to manufacturer's written startup instructions.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain steam condensate pumps.

End of Section

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Section 23 25 00

HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following HVAC water-treatment systems:

1. Bypass chemical-feed equipment and controls.
2. Chemical treatment test equipment.
3. HVAC water-treatment chemicals.
4. Water filtration units for HVAC makeup water.

1.3 PERFORMANCE REQUIREMENTS

A. All chemicals and formulations prescribed for the cleaning and treatment of process water systems at the University must meet the following specified criteria:

1. They must be ecologically compatible so that any discharge will not create an environmental impact. All chemicals and formulations must comply with NY State SPDES (State Pollution Discharge Elimination System) regulations and be free of compounds listed by the EPA on the Priority Pollutant List as defined by 40 CFR Part 423 Appendix A.

2. They must be industrial and toxicologically safe so as to minimize personnel and equipment exposure to hazardous conditions.

3. Every effort must be made to maintain a sense of uniformity in chemical formulation to insure a line of continuity. Deviation from existing formulations that are applied across the University are not allowed. This relieves the University of any burden that arises from trying to maintain adequate protection using numerous treatments.

4. Ethylene Glycol (CAS 107-21-1): This material is considered a hazardous substance per the 6 NYCRR Part 598. Any release (defined as unauthorized pumping, pouring, emitting, emptying, overfilling, spilling, leaking, leaching or disposing, directly or indirectly into the environment) in the amount of 1 pound of ethylene glycol into the air, land or water must be reported to the New York State Department of Environmental Conservation. For this reason, Cornell prohibits the use of ethylene glycol.

B. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.

C. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

B. Manufacturer Seismic Qualification Certification: Submit certification that water softeners, water filtration units and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Other Informational Submittals:

1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.

2. Water Analysis: Illustrate water quality available at Project site.
3. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, water softeners, water filtration units, and controllers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.7 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for cooling, chilled-water piping, heating, hot-water piping, condenser-water piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.

2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.

3. Periodic field service and consultation.

4. Customer report charts and log sheets.

5. Laboratory technical analysis.

6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

1.8 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

1.9 APPROVAL PROCESS

1. All materials proposed for application must have the prior approval of Environmental Health and Safety, Facilities Engineering and the Facilities Management Water Treatment Lab. In order to thoroughly evaluate the products performance, it is recommended that the following be submitted at the time of proposal:
   a. Safety Data Sheets (SDS) for all products that are to be applied, which shall contain the complete formulation. Further documentation of

qualitative composition must be included if SDS's do not supply all product(s) components.

b. Product Data Sheets specifying overall product description and application guidelines

1.10 Methods of analysis for determining product residuals. Proposals should specify specific qualitative and quantitative procedures of evaluating actual product levels. They should also include recommended parameters for all products, expressed in either terms of parts per million or milligrams per liter.

A. Expected performance levels of products: this should include expected corrosion rates, expressed in mils per year. If the product is of a biostatic nature, what levels of biological growth

PART 2 - PRODUCTS

2.1 Contractor to engage Metro Chemical for all chemical treatment on this project.

2.2 CLEANING

A. Cleaning procedures for newly installed systems shall be as follows:

B. Step 1: Adjust all control valves and balancing valves to full open position during the cleaning and treatment process.

C. Step 2: Fill system and add a general dispersant for iron, mud, silt, and microbiological matter at a concentration recommended by the chemical manufacturer. Pay particular attention to the type of material being cleaned. (steel, copper, aluminum, etc.) Test for concentration. Circulate solution for 4-8 hours or as specified by the cleaner manufacturers recommendations. Flush system until system water pH and iron levels are consistent with the feed domestic water levels. Clean strainers and dead end piping legs. Provide test results to the Facilities Management Water Treatment Lab.

D. Step 3: Arrange for inspection by a representative from the Facilities Management Water Treatment Lab before proceeding to chemical treatment.

E. For extensions to existing building systems, the above cleaning procedures shall be followed. Provide temporary piping, valving, and pumping system isolated from the existing building system as needed to perform cleaning procedures prior to final connection to the existing building system.

F. TREATMENT CHEMICALS

1. Chemicals shall not be used to treat chilled water systems connected to the campus chilled water loop.

2. Chilled water systems connected to the campus chilled water loop shall be cleaned, inspected, and filled with potable water. Notify The Central Energy Plant

(CEP) for permission to begin circulating water into the campus chilled water loop.

3. Existing Systems – Field verify existing treatment chemical quantities to ensure the correct quantities are added back to the system following construction.

4. Treatment chemicals for hydronic heating and chilled water cooling systems, not connected to the campus chilled water loop, shall be as follows:

5. Non-Glycol Systems (non-potable): After cleaning and inspection, immediately add a molybdate based corrosion inhibitor. Acceptable corrosion inhibitors shall include a combination of sodium molybdate, sodium hydroxide, tolytriazole and organic polymers. Test for residual concentrations as follows:
   a. Molybdate (M06): 150 ppm (hot water systems)
   b. pH: 8.3-9
   c. Tolytriazole (TTA): 10-20 ppm

6. Non-Glycol System (potable): Refer to Section 223500 for acceptable treatment chemicals for potable water applications.

7. Glycol Heating Systems: After cleaning and inspection, drain system then refill with glycol as specified below.

8. Glycol Cooling Systems: After cleaning and inspection, drain system then refill with glycol solution at a concentration recommended by the manufacturer, with nitrate and tolytriazole corrosion inhibitors.

9. The water to be added to glycol solutions shall meet manufacturer's standards for quality.

10. Glycol for heating systems shall be specifically formulated to the following specifications:
    a. Propylene glycol: 400,000 ppm (40%)
    b. Nitrate: 1500 ppm
    c. Tolytriazole: 20 ppm
    d. Water: Balance
    e. Color: Olive Green
    f. Preferred Manf/Material: Metro PG#36

11. Arrange for inspection by a representative from the Facilities Management Water Treatment Lab prior to final acceptance.

G. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.

2. Molded cover with recess for mounting pump.

3. Capacity: 50 gal. (189 L).

H. Chemical Solution Injection Pumps:

1. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.

2. Adjustable flow rate.

3. Metal and thermoplastic construction.

4. Built-in relief valve.

5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

I. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints

J. Injection Assembly:

1. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.

2. Ball Valve: Three or Two-piece, stainless steel as described in "Stainless-Steel Pipes and Fittings" Article below; and selected to fit quill.

3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.

4. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).

K. IDENTIFICATION

1. Provide a three ring binder for each hydronic system treated with chemicals that include the following information:

2. SDS, product data sheets, chemical type, test points, control limits and system volume.

3. Direction to drain system to sanitary drain.

4. System volume shall be stenciled on the system expansion tank in a visible location.

L. TREATMENT EQUIPMENT

1. Bag filters shall be provided for system volumes exceeding 500 gallons.

2. Bag filters or chemical pot feeders shall be utilized for system volumes below 500 gallons.

3. Refer to Cornell Standard Detail 3.2.5 Heat Transfer Package Schematic for preferred location of treatment equipment.

2.3 AUTOMATIC GLYCOL FEEDER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Wessels Company
2. Neptune
3. Approved equal

B. General: provide and install a completely pre-fabricated/preassembled package glycol feeder system with: single point power connection, injection pump, fluid holding tank, interconnecting piping and wiring, and control panel.

C. Pump:

1. Material: Bronze
2. Fluid flow rate: per scheduled data
3. Discharge pressure: per scheduled data

D. Tank: shall be constructed of polyethylene with a four-leg steel stand with attachment bolts at each leg. Tank shall have upper and lower steel support banding. Steel support stand to be painted with corrosion resistant enamel.

E. Piping:

1. Piping to be rated for system pressure and use within a pressurized system.

2. Pump suction piping: to be constructed of PVC tubing and fittings. PVC shutoff vavle and strainer to be furnished.

3. Pump discharge piping: constructed of schedule 40 brass and brass fittings. Discharge to come equipped with pressure switch, pressure gage, isolation valve, check valve, and relief valve. Relief valve to be piped back to the holding tank.

F. Control Panel:
1. 115 volt, single phase power connection
2. NEMA 4X enclosure
3. HOA switch with running light and starter.

G. Level switch: low level switch shall engage a low level alarm. Alarm shall be issued to the central BAS system as well as a local, audible, alarm.

2.4 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, and hardness.

B. Sample Cooler:

1. Tube: Sample.

a. Size: NPS 1/4 (DN 8) tubing.
b. Material: ASTM A 666, Type 316 stainless steel.
c. Pressure Rating: Minimum 2000 psig (13 790 kPa).
d. Temperature Rating: Minimum 850 deg F (454 deg C).

2. Shell: Cooling water.

a. Material: ASTM A 666, Type 304 stainless steel.
b. Pressure Rating: Minimum 250 psig (1725 kPa).
c. Temperature Rating: Minimum 450 deg F (232 deg C).

3. Capacities and Characteristics:

a. Tube: Sample.

1) Flow Rate: 0.25 gpm (0.016 L/s).
2) Entering Temperature: 400 deg F (204 deg C).
3) Leaving Temperature: 88 deg F (31 deg C).
4) Pressure Loss: 6.5 psig (44.8 kPa).

b. Shell: Cooling water.

1) Flow Rate: 3 gpm (0.19 L/s).
2) Entering Temperature: 70 deg F (21 deg C).
3) Pressure Loss: 1.0 psig (6.89 kPa).

C. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.

1. Two-station rack for closed-loop systems.
2. Four-station rack for open systems.

2.5 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.

B. Water Softener Chemicals:

1. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. (69 kg/cu. m) of calcium carbonate of resin when regenerated with 15 lb (6.8 kg) of salt.

2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.

2.6 INHIBITED PROPYLENE GLYCOL

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Dow Chemical Company (The).
2. Dynalene.
3. Fremont Industries.
4. Houghton Chemical Corp.

B. Inhibited Propylene Glycol:

1. Propylene glycol with inhibitor additive, to provide freeze protection for heat-transfer fluid and corrosion protection for carbon-steel, brass, copper, stainless steel, and cast-iron piping and fittings.

2. Inhibitor creates a passive layer on all surfaces that contact propylene glycol to prevent corrosion and stabilizes fluid pH, to compensate for acids formed from glycol degradation.

3. pH value shall be maintained between 9.0 and 9.5, with reserve alkalinity greater than 50 mL.

4. Operating Temperature Range: minus 50 deg F to 250 deg F

5. Concentrated inhibited propylene glycol is to be 95.5 percent propylene glycol by weight and 4.5 percent performance additives.

6. Concentrated inhibited propylene glycol is mixed with water in proper proportion specified by the manufacturer to provide freeze protection to minus 20 deg F. Premixed heat-transfer fluid may be used, or glycol/water mixture may be prepared at the time of installation. Use only deionized water for mixing.

7. Provide only propylene glycol that is specifically blended for HVAC application. Automotive-type antifreeze is unacceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Bypass Feeders: Install in closed hydronic systems, including hot-water heating and chilled water and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.

2. Install water meter in makeup water supply.

3. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.

4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.

5. Install a swing check on inlet after the isolation valve.

G. Install automatic fluid make-up equipment for glycol water system and include the following:

1. Chemical solution tanks.

2. Chemical solution injection pumps.

3. Water meter in makeup supply to system.

4. Pressure switch to operate injection pump as necessary to maintain glycol system pressure.

5. Contractor to provide enough glycol for the entire snowmelt system and all HVAC Systems. Coordinate with approved submittals to calculate the quantities required and submit readings to verify the loops have been filled.

3.3 WATER SOFTENER INSTALLATION

A. Install water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

C. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.

D. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

E. Install water-testing sets on wall adjacent to water softeners.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 "General-Duty Valves for HVAC Piping."

E. Refer to Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.

F. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Provide a flush and drain procedure to "clean" the system before returning condensate back to Campus.

2. Cleaning procedures for newly installed systems:

   Step 1: Adjust all control valves and balancing valves to full open position during the cleaning and treatment process;

   Step 2: Fill system and add a general dispersant for iron, mud, silt, and microbiological matter at a concentration recommended by the chemical manufacturer. Pay particular attention to the type of material being cleaned (steel, copper, aluminum, etc.) Test for concentration. Circulate solution for a minimum of eight hours. Flush system until system water pH and iron levels are consistent with the feed domestic water levels. Clean strainers and dead end piping legs. Provide test results to the Facilities Management Water Treatment Lab;

   Step 3: Arrange for inspection by a representative from the Facilities Management Water Treatment Lab before proceeding to chemical treatment.

3. Inspect field-assembled components and equipment installation, including piping and electrical connections.

4. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.

5. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.

6. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.

7. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

8. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.

9. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.

10. Repair leaks and defects with new materials and retest piping until no leaks exist.

D. Remove and replace malfunctioning units and retest as specified above.

E. At eight-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are

maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.

F. Comply with ASTM D 3370 and with the following standards:

1. Silica: ASTM D 859.
2. Steam System: ASTM D 1066.
3. Acidity and Alkalinity: ASTM D 1067.
4. Iron: ASTM D 1068.
5. Water Hardness: ASTM D 1126.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment. Refer to Section 017900 "Demonstration and Training."

B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

End of Section

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Section 23 29 23

VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. Related Requirements:

1. Section 262419 "Motor-Control Centers" for VFCs installed in motor-control centers.

1.3 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. LED: Light-emitting diode.

F. NC: Normally closed.

G. NO: Normally open.

H. OCPD: Overcurrent protective device.

I. PID: Control action, proportional plus integral plus derivative.

J. RFI: Radio-frequency interference.

K. VFC: Variable-frequency motor controller. Also referred to as VFD or variable frequency drives and VSD or variable speed drives.

1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

1. Include dimensions and finishes for VFCs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.

1. Include mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Required working clearances and required area above and around VFCs.
2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
3. Show support locations, type of support, and weight on each support.
4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Product Certificates: For each VFC from manufacturer.

D. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
b. Manufacturer's written instructions for setting field-adjustable overload relays.
c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
e. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Yaskawa Electric America, Inc.; or a comparable product by one of the following:

1. ABB (Electrification Products Division).
2. Eaton.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

B. Application: Variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: To match upstream panelboard or as indicated as required based on the short circuit study specified in Section 260573 "Overcurrent Protective Device Coordination Study And Arc Flash Hazard Analysis."
7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 5 percent.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

I. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.

8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault..

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: UL 489, molded-case switch, with power fuse block and current-limiting fuses with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
3. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFCs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.

3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

    a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

    a. A minimum of two programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc.
    b. A minimum of six multifunction programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:

    a. 0- to 10-V dc.

b. 4- to 20-mA dc.
c. Potentiometer using up/down digital inputs.
d. Fixed frequencies using digital inputs.

3. Output Signal Interface: A minimum of two programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc), which can be configured for any of the following:

a. Output frequency (Hz).
b. Output current (load).
c. DC-link voltage (V dc).
d. Motor torque (percent).
e. Motor speed (rpm).
f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.
b. Set point speed reached.
c. Fault and warning indication (overtemperature or overcurrent).
d. PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: Two.

G. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.

1. Hardwired Points:

a. Monitoring: On-off status.
b. Control: On-off operation.

2. Communication Interface: Comply with ASHRAE 135. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

H. Interface with the Fire Alarm System: Interface with the fire alarm system to allow remote operation of all VFD’s serving stair pressurization system by the fire alarm system.

1. Hardwired Points:

a. Monitoring: On-off status.

b. Control: On-off operation for all fans with VFD's.
c. Request for run: On operation for all fans other than stair pressurization fans.

2. Communication Interface: Communication shall interface with DDC system for the fire alarm system to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC. Provide BACnet MSTP integration protocol for integration with DDC.

2.5 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.

B. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

2.6 OPTIONAL FEATURES

A. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it, and generates fault indications when overload protection activates.

1. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.
2. Configure to allow two motors to operate separately; operator selectable via local or remote switch or contact closures; single overload relay for both motors; separate output magnetic contactors for each motor.
3. Configure to allow two motors to operate simultaneously and in a lead/lag mode, with one motor operated at variable speed via the power converter and the other at constant speed via the bypass controller; separate overload relay for each controlled motor.

B. Automatic Damper control circuit with end-of-travel feedback capability. The automatic damper control circuit shall close a dry contact upon a manual or automatic start (run) command to open a control damper before the motor is allowed to operate in normal or bypass mode regardless of the source of the run command. When the damper is fully open (via damper position device-normally open dry contact) the motor will be allowed to operate. If any of the VFD safety interlock inputs are activated (freezestat, pressure safety, damper end switch, smoke alarm, etc.) the motor will stop (normal or bypass mode) and the automatic damper shall close. Provide time delay relay to allow the automatic damper to remain open until the motor stops.

C. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.

D. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.

E. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station, this password-protected input:

1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
2. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
3. Forces VFC to transfer to bypass mode and operate motor at full speed.
4. Causes display of override mode on the VFC display.
5. Reset VFC to normal operation on removal of override signal automatically.

F. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

G. Remote digital operator kit.

H. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

2.7 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 4X, stainless steel.
3. Kitchen or Wash-Down Areas: Type 4X, stainless steel.
4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.8 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons: [Covered].
2. Pilot Lights: Push to test.
3. Selector Switches: Rotary type.

B. Reversible NC/NO bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Digital Meters:

1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Cooling Fan and Exhaust System: For NEMA 250, Type 1; UL 508 component recognized: Supply fan, with composite intake and exhaust grills and filters;-V ac; obtained from integral CPT.

I. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

J. Spare control-wiring terminal blocks; unwired.

2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Floor-Mounting Controllers: Install VFCs on 4-inch nominal thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

1. Curbs and roof penetrations are specified in Section 077200 "Roof Accessories."
2. Structural-steel channels are specified in Section 260529 "Hangers and Supports for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in each fusible-switch VFC.

F. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

G. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

I. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect and Owner before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. .

3.7 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set the taps on reduced-voltage autotransformer controllers.

C. Set field-adjustable circuit-breaker trip ranges. Mechanical contractor to coordinate this with the electrical contractor.

D. Set field-adjustable pressure switches.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

End of Section

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Section 23 31 13

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round and flat-oval ducts and fittings.
3. Double wall round and flat-oval ducts and fittings.
4. Sheet metal materials.
5. Duct liner.
6. Sealants and gaskets.
7. Hangers and supports.
8. Seismic-restraint devices.
9. Exterior duct and fittings.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.

2. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.

3. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.

2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.

3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.

2. Factory- and shop-fabricated ducts and fittings.

3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.

4. Elevation of top of ducts.

5. Dimensions of main duct runs from building grid lines.

6. Fittings.

7. Reinforcement and spacing.

8. Seam and joint construction.

9. Penetrations through fire-rated and other partitions.

10. Equipment installation based on equipment being used on Project.

11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.

12. Hangers and supports, including methods for duct and building attachment, seismic restraints and vibration isolation.

A. Delegated-Design Submittal:

1. Sheet metal thicknesses.

2. Joint and seam construction and sealing.

3. Reinforcement details and spacing.

4. Materials, fabrication, assembly, and spacing of hangers and supports.

5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.

2. Suspended ceiling components.

3. Structural members to which duct will be attached.

4. Size and location of initial access modules for acoustical tile.

5. Penetrations of smoke barriers and fire-rated construction.

6. Items penetrating finished ceiling including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.

2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.

3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

D. Mockups:

1. Before installing duct systems, build mockups representing static-pressure classes in excess of 3-inch wg. Build mockups to comply with the following requirements, using materials indicated for the completed Work:

   a. Five transverse joints.
   b. One access door(s).
   c. Two typical branch connections, each with at least one elbow.
   d. One fire damper(s).
   e. Perform leakage tests specified in "Field Quality Control" Article. Revise mockup construction and perform additional tests as required to achieve specified minimum acceptable results.

2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements,

materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Lindab Inc.
    b. McGill AirFlow LLC.
    c. SEMCO Incorporated.
    d. Sheet Metal Connectors, Inc.
    e. Spiral Manufacturing Co., Inc.
    f. Approved Equal.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. McGill AirFlow LLC.
2. SEMCO Incorporated.
3. Sheet Metal Connectors, Inc.
4. Spiral Manufacturing Co., Inc.
5. Approved Equal.

B. Double wall lined ductwork with inner perforated liner to be used where round ductwork is lined, concealed or exposed, to ensure all fittings and transitions are internally lined.

C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

D. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    a. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.

2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
    b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 50% percent.

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.

2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.

3. Coat insulation with antimicrobial coating.

4. Cover insulation with polyester film complying with UL 181, Class 1.

G. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.

1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at75 deg F (24 deg C) mean temperature.

2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Seal Class A

2. Galvanized Coating Designation: G60.

3. Finishes for Surfaces Exposed to View: Mill phosphatized.

4. Exposed ductwork to be painted: Mill phosphatized.
   a. Coordinate painting requirements with section 09 91 13 Interior Painting.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.5 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. CertainTeed Corporation; Insulation Group.
b. Johns Manville.
c. Knauf Insulation.
d. Owens Corning.
e. Approved Equal.

2. Sound absorption coefficients and NRC shall meet or exceed the following when tested in accordance with ASTM C 423 using an "A" mounting:

Thickness	Octave band sound absorption coefficients at octave band center frequency						
	125	250	500	1000	2000	4000	NRC
1”	0.1	0.2	0.7	0.9	1	1	0.7

3. Maximum Thermal Conductivity:

1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

4. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

5. Solvent-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

a. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Bonded Logic, Inc.
b. Reflectix Inc.
c. Approved Equal.

2. Sound absorption coefficients and NRC shall meet or exceed the following when tested in accordance with ASTM C 423 using an "A" mounting:

Thickness	Octave band sound absorption coefficients at octave band center frequency						
	125	250	500	1000	2000	4000	NRC
1”	0.1	0.2	0.7	0.9	1	1	0.7

3. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at75 deg F mean temperature when tested according to ASTM C 518.

4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to ASTM E 84; certified by an NRTL.

5. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

a. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

D. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

3. Butt transverse joints without gaps, and coat joint with adhesive.

4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.

7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

   a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

2. Tape Width: 3 inches.

3. Sealant: Modified styrene acrylic.

4. Water resistant.

5. Mold and mildew resistant.

6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.

7. Service: Indoor and outdoor.

8. Service Temperature: Minus 40 to plus 200 deg F.

9. Substrate: Compatible with galvanized sheet steel, stainless steel, or aluminum.

10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.

2. Solids Content: Minimum 65 percent.

3. Shore A Hardness: Minimum 20.

4. Water resistant.

5. Mold and mildew resistant.

6. VOC: Maximum 75 g/L (less water).

7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.

8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel, stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.

2. Base: Synthetic rubber resin.

3. Solvent: Toluene and heptane.

4. Solids Content: Minimum 60 percent.

5. Shore A Hardness: Minimum 60.

6. Water resistant.

7. Mold and mildew resistant.

8. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

9. VOC: Maximum 395 g/L.

10. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

11. Maximum Static-Pressure Class: 10-inch wg, positive or negative.

12. Service: Indoor or outdoor.

13. Substrate: Compatible with galvanized sheet steel, stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.

2. Type: S.

3. Grade: NS.

4. Class: 25.

5. Use: O.

6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.

2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.

3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.8 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.
4. Kinetics Noise Control.
5. Loos & Co.; Cableware Division.
6. Mason Industries.
7. TOLCO; a brand of NIBCO INC.
8. Unistrut Corporation; Tyco International, Ltd.
9. Approved Equal.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service or an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.9 EXTERIOR DUCT AND ACCESSORIES

A. Manufactures: Subject to compliance with requirements, provide products by one of the following:
1. Thermaduct
2. Pro-R Ductwork
3. Equal or approved other

B. General requirements: Provide a highly efficient code compliant pre-insulated outdoor air distribution system designed to provide high R-values (R-16.2). Thermaduct is a fiber-free closed cell foam insulation, factory bonded to a high impact strength UV stable 1000 micron exterior vinyl shell. Ductwork to be provided with weather proof outdoor cladding and to be 100% water tight.

C. Compliance Testing: Comply with the following standards:

1. UL 723, UL 181, 90A, 90B Interior; ASTM D-638, ASTM D790, ASTM D-256, ASTM D-4226, ASTM D-4216, ASTM D-792, ASTM D-2240, ASTM D-696, ASTM D-648, UL-94 Exterior Cladding;

D. Vapor Barrier: Autohesively bonded aluminum foil with zero permeability 1000 micron UV stable vinyl.

E. Fire/Smoke Performance:

1. UL 723 Flame spread / smoke development interior.

F. Density: Provide with a shell that has a tensile strength of 6,350 psi.

G. Thermal Conductivity: K = 0.146 BTU/in/ft2/hr./degree F

H. Color: Polar white with reflective sheen.

I. Warranty: 10 Years

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round and flat-oval ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install kitchen commercial kitchen exhaust ducts in strict accordance with NFPA 96.

B. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

C. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 12 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.

D. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 DUCT SEALING

A. All ductwork and plenums shall be constructed to SMACNA “Seal Class A”; all transverse joints, longitudinal seams and duct wall penetrations shall be sealed.

B. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.

2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

5. Do not use powder-actuated concrete fasteners for precast plank unless approved by precaster.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" and ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.

2. Brace a change of direction longer than 12 feet (3.7 m).

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service or an agency acceptable to authorities having jurisdiction].

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.7 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Systems designed to operate at 3-inches w.c. and below: 25% percent of the duct system shall be leak tested. The Consultant/Owner shall randomly choose the sections of ductwork to be tested during the Construction Phase. If any of the original sections fail the leakage test, another 25% of the duct shall be chosen to be tested. If any section of the second 25% fails, the entire system shall be leakage tested.

2. Systems designed to operate in excess of 3-inches w.c.: The entire system shall be leak tested.

3. All ducts risers, and ducts located in shafts to be fully tested prior to enclosure.

4. Testing shall be performed in accordance with the SMACNA Air Duct Leakage Test Manual. Leakage testing shall be witnessed by representatives from Cornell University and the Project Engineer of Record.

5. TAB contractor is to witness 25% of the duct leakage testing

6. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

7. Test for leaks before applying external insulation and enclosure within shafts.

8. Conduct Interior supply, return, and general exhaust systems. Duct leakage testing acceptance criteria: Interior supply, return, and general exhaust systems: 5% system leakage, tested at 1.25 times the expected operating static pressure."

9. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.10 DUCT CLEANING

A. All existing ductwork connected to AHU-C2 and AHU-C6 to be fully cleaned prior to connection to the new AHUs.

B. All new ductwork and ductwork noted as existing to remain is to be protected from moisture, construction debris and dust, and other foreign materials during construction.

C. Where ductwork is not protected during construction, clean new duct system(s) before testing, adjusting, and balancing.

D. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.

2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.

3. Remove and reinstall ceiling to gain access during the cleaning process.

E. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

F. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).

2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

4. Coils and related components.

5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.

6. Supply-air ducts, dampers, actuators, and turning vanes.

7. Dedicated exhaust and ventilation components and makeup air systems.

G. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.11 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.12 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts:

1. Ducts Connected to Split Systems and Terminal Units:
   1) Minimum SMACNA Seal Class: A.

2. Ducts Connected to Variable-Air-Volume Air-Handling Units:
   a. Minimum SMACNA Seal Class: A.

3. Ducts Connected to Equipment Not Listed Above:
   a. Minimum SMACNA Seal Class: A.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units and Terminal Units:
   a. Minimum SMACNA Seal Class: A.

2. Ducts Connected to Air-Handling Units:
   a. Minimum SMACNA Seal Class: A.

3. Ducts Connected to Equipment Not Listed Above:
   a. Minimum SMACNA Seal Class: A.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
   a. Minimum SMACNA Seal Class: A.

2. Ducts Connected to Air-Handling Units:
   a. Minimum SMACNA Seal Class: A .

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Air-Handling Units:
   a. Minimum SMACNA Seal Class: A.

F. External Supply/Return ductwork:

1. Ductwork located outdoors:
   a. Minimum SMACNA Seal Class: A.

G. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel or Carbon steel coated with zinc-chromate primer.

2. Stainless-Steel Ducts:

   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.

3. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.

H. Liner:

1. Liner is only acceptable on transfer ducts.

2. Transfer Ducts: Fibrous glass, Type I or Flexible elastomeric 1 inch thick.

I. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

      1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

J. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

End of Section

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Section 23 33 00

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Combination fire smoke dampers.
7. Smoke dampers.
8. Flange connectors.
9. Duct silencers.
10. Turning vanes.
11. Remote damper operators.
12. Duct-mounted access doors.
13. Flexible connectors.
14. Flexible ducts.
15. Duct accessory hardware.

B. Related Requirements:
1. Section 283111 "Digital, Addressable Fire-Alarm System" for duct-mounted fire and smoke detectors.
2. Section 283112 "Zoned (DC-Loop) Fire-Alarm System" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. For duct silencers, include pressure drop, dynamic insertion loss data and regenerated noise data at each octave band from 63Hz to 8kHz. Include breakout noise calculations for high transmission loss casings.

B. LEED Submittals:
1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

2. Product Data for Prerequisite EA 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
   1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
      a. Special fittings.
      b. Manual volume damper installations.
      c. Control-damper installations.
      d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
      e. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

1.7 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G60.
   2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No 3 finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Greenheck Fan Corporation.
   2. Nailor Industries Inc.
   3. Ruskin Company.
   4. Approved Equal.

C. Description: Gravity balanced.

D. Maximum Air Velocity: 1000 fpm.

E. Maximum System Pressure: 1-inch wg

F. Maximum Backdraft Pressure: 4.5 Inches wg.

G. Frame: Hat-shaped, 0.09-inch- thick extruded aluminum, with front and rear flange and mitred corners.

H. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch width, 0.025-inch-thick roll-formed aluminum with sealed edges.

I. Blade Action: Parallel.

J. Blade Seals: Extruded vinyl, mechanically locked.

K. Blade Axles:
1. Material: Corrosion resistant synthetic, locked to blade and formed as a single piece with bearing.

L. Accessories:
1. Adjustment device to permit setting for varying differential static pressure.
2. Screen Mounting: Rear mounted.
3. Screen Material: Aluminum.
4. Screen Type: Bird.
5. 90-degree stops.

2.4 BAROMETRIC RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Ruskin Company.
4. Approved Equal.

C. Suitable for horizontal or vertical mounting.

D. Maximum Air Velocity: 1000 fpm.

E. Maximum System Pressure: 2-inch wg.

F. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch width, 0.025-inch-thick roll-formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Extruded vinyl, mechanically locked.

I. Blade Axles:
   1. Material: Corrosion resistant synthetic, locked to blade and formed as a single piece with bearing.

J. Accessories:
   1. Adjustment device to permit setting for varying differential static pressure.
   2. Screen Mounting: Rear mounted.
   3. Screen Material: Aluminum.
   4. Screen Type: Bird.
   5. 90-degree stops.

2.5 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Nailor Industries Inc.
      b. Ruskin Company.
      c. Trox USA Inc.
      d. Approved Equal.
   3. Standard leakage rating, with linkage outside airstream.
   4. Suitable for horizontal or vertical applications.
   5. Frames:
      a. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel.
      b. Mitered and welded corners.
      c. Flanges for attaching to walls and flangeless frames for installing in ducts.
   6. Blades:
      a. Multiple or single blade.
      b. Opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Galvanized steel, 0.064 inch thick.
   7. Blade Axles: Galvanized steel.
   8. Bearings:
      a. Molded synthetic.
      b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
   9. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Nailor Industries Inc.
      b. Ruskin Company.
      c. Trox USA Inc.
      d. Approved Equal.

3. Standard leakage rating, with linkage outside airstream.
4. Suitable for horizontal or vertical applications.
5. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
   a. Multiple or single blade.
   b. Opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
   e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
7. Blade Axles: Nonferrous metal.
8. Bearings:
   a. Molded synthetic.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
9. Tie Bars and Brackets: Aluminum.

C. Low-Leakage, Aluminum, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Nailor Industries Inc.
   b. Ruskin Company.
   c. Trox USA Inc.
   d. Approved Equal.
3. Comply with AMCA 500-D testing for damper rating.
4. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
5. Suitable for horizontal or vertical applications.
6. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
7. Blades:
   a. Multiple or single blade.
   b. Parallel or opposed-blade design.
   c. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
8. Blade Axles: Galvanized steel.
9. Bearings:
   a. Oil-impregnated bronze.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
10. Blade Seals: Felt.
11. Jamb Seals: Cambered aluminum.
12. Tie Bars and Brackets: Aluminum.
13. Accessories:
    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Jackshaft:
1. Size: 0.5-inch diameter.

2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

E. Damper Hardware:
1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.6 CONTROL DAMPERS

A. Refer to Specification 230923.12 for control damper requirements.

2.7 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

B. Assemblies shall be UL listed.

C. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Greenheck Fan Corporation.
2. Ruskin Company.
3. Approved Equal.

D. Type: Static; rated and labeled according to UL 555 by an NRTL.

E. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

F. Fire Rating: 1-1/2 and 3 hours.

G. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, Multiple Blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
1. Application: Provide curtain type dampers when one ductwork allows a single section damper. Multiple Blade type dampers shall be utilized when a single section damper is not available.

H. Mounting Sleeve: Factory- or field-installed UL-approved sleeve, galvanized sheet steel.
1. Sleeve seams shall be continuously welded or sealed, and the transverse joint should be a sealed UL-approved flanged duct sleeve connection.
2. Minimum Thickness: 0.138 inch or 0.39 inch thick, as indicated, and of length to suit application.

3. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

I. Mounting Orientation: Vertical or horizontal as indicated.

J. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

K. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

L. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

M. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.8 COMBINATION FIRE AND SMOKE DAMPERS

A. Assemblies shall be UL listed.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
2. Ruskin Company.
3. Or Approved equal.

C. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

D. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 2000-fpm (10-m/s) velocity.

E. Fire Rating: 1-1/2 and 3 hours.

F. Frame: Hat-shaped channel, roll formed galvanized steel with interlocking gusseted corners. Structurally equivalent to 13 gauge (2.3 mm) U-channel type frame. Low profile head and sill on sizes less than 13 inches (330 mm) high.

G. Heat-Responsive Device: Resettable, 165 deg F (74 deg C) rated, fire-closure device.

H. Heat-Responsive Device: Electric resettable device and switch package, factory installed, rated.

I. Blades: 6 inch (152 mm) maximum width, double skinned true airfoil, roll formed galvanized steel. Structurally equivalent to 14 gauge.

J. Blade Seals: Silicone rubber integrally rolled and mechanically fastened to blade edge (glue-on or grip-type seals are not acceptable).

K. Jamb Seals: Stainless steel, flexible metal compression type.

L. Axles: Minimum ½" (13 mm) diameter plated steel hex-shaped, mechanically attached to blade.

M. Leakage: Class I.

N. Rated pressure and velocity to exceed design airflow conditions.

O. Mounting Sleeve: The assembly shall be provided with an integral UL-approved sleeve. Jackshaft penetrations shall be provided with a factory shaft seal. Sleeve seams shall be continuously welded or sealed, and the transverse joint should be a sealed UL-approved flanged duct sleeve connection. Standard 16 inches long x 20 gauge (406 mm x 1.0 mm), factory installed galvanized sheet steel.

P. Master control panel for use in dynamic smoke-management systems.

Q. Damper Motors: Modulating or two-position action. Damper test switch, Remote annunciation indicator.

R. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "direct digital control (ddc) for hvac."
   3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
   4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
   5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
   6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
   7. Electrical Connection: 115 V, single phase, 60 Hz

S. On a loss of normal power fire smoke dampers should close and remain so until power is restored.

T. Accessories:
   1. Auxiliary switches for position indication, open and closed (2) per damper.
   2. Test and reset switches, remote mounted.

2.9 SMOKE DAMPERS

A. Assemblies shall be UL listed.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Greenheck Fan Corporation.
   2. Ruskin Company.
   3. Or Approved Equal.

C. General Requirements: Label according to UL 555S by an NRTL.

D. Frame: Damper frame shall be 16 ga. galvanized steel formed into a 5" x 1" structural hat channel. Top and bottom frame members on dampers less than 17" high shall be low profile design to maximize the free area of these smaller dampers. Frame shall be 4-piece construction with 1 ½" (minimum) integral overlapping gusset reinforcements in each corner to assure square corners and provide maximum resistance to racking.

E. Blades: Damper blades shall be 16 ga. galvanized steel strengthened by three longitudinal 1" deep Vee grooves running the entire length of each blade. Each blade shall be symmetrical relative to its axle pivot point, presenting identical performance characteristics with air flowing in either direction through the damper. Provide symmetrical blades of varying size as required to completely fill the damper opening.

F. Blade Stops: Each blade stop (at top and bottom of damper frame) shall occupy no more than ½" of the damper opening area to allow for maximum free area and to minimize pressure loss across the damper.

G. Seals:
   1. Blade Edge: Blade seals shall be extruded silicone rubber permanently bonded to the appropriate blade edges.
   2. Jamb: Flexible stainless steel compression type.

H. Linkage: Concealed in jamb.

I. Axles: Minimum ½ inch dia. plated steel.

J. Bearings: Axle bearings shall be sintered bronze sleeve type rotating in polished extruded holes in the damper frame.

K. Leakage: Class I.

L. Rated pressure and velocity to exceed design airflow conditions.

M. Mounting Sleeve: The assembly shall be provided with an integral UL-approved sleeve. Jackshaft penetrations shall be provided with a factory shaft seal. Sleeve seams shall be continuously welded or sealed, and the transverse joint should be a sealed UL-approved flanged duct sleeve connection. Factory-installed, Standard 16 inches long x 20 gauge (406 mm x 1.0 mm), factory installed galvanized sheet steel.

N. Damper Motors: two-position action. Damper test switch, Remote annunciation indicator.

O. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "direct digital control (ddc) for hvac."
   3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
   4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
   5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
   6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
   7. Electrical Connection: 115 V, single phase, 60 Hz

P. Accessories:
   1. Auxiliary switches for signaling fan control or position indication.
   2. Test and reset switches, damper mounted.

2.10 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Ductmate Industries, Inc.
   2. Nexus PDQ; Division of Shilco Holdings Inc.
   3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
   4. Approved Equal.

C. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

D. Material: Galvanized steel.

E. Gage and Shape: Match connecting ductwork.

2.11 DUCT SILENCERS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Dynasonics.
   2. Industrial Acoustics Company
   3. Vibro-Acoustics.
   4. Approved Equal.

C. General Requirements:
   1. Factory fabricated.
   2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
   3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Shape:
   1. Rectangular straight with splitters or baffles.
   2. Rectangular elbow with splitters or baffles.

E. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel, 0.034 inch thick.

F. Inner Casing and Baffles: ASTM A 653/A 653M, G90 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch- diameter perforations.

G. Connection Sizes: Match connecting ductwork unless otherwise indicated.

H. Principal Sound-Absorbing Mechanism:
   1. Dissipative type with fill material.
      a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression.
      b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.
   2. Lining: Bonded glass fiber matting with addition of 1 mil Mylar film when explicitly specified as "encapsulated".

I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
   1. Joints: Lock formed and sealed, continuously welded, or flanged connections.
   2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
   3. Reinforcement: Cross or trapeze angles for rigid suspension.

J. Source Quality Control: Test according to ASTM E 477.
   1. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
   2. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

K. Performance: Achieve insertion loss, regenerated noise, and static pressure drop for CFM flow required per schedules on Drawings.

2.12 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Ductmate Industries, Inc.
2. METALAIRE, Inc.
3. SEMCO Incorporated.
4. Approved Equal.

C. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Double wall.

2.13 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Greenheck Corporation
2. Metropolitan Air Technology
3. Young Regulator Company.
4. Approved Equal.

C. Description: Cable system designed for remote manual damper adjustment.

D. Cable: Stainless steel.

E. Wall-Box Mounting: Recessed.

F. Wall-Box Cover-Plate Material: Stainless steel.

2.14 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Flexmaster U.S.A., Inc.
   2. Greenheck Fan Corporation.
   3. Nailor Industries Inc.
   4. Approved Equal.

C. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
   1. Door:
      a. Double wall, rectangular.
      b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
      c. Vision panel.
      d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
      e. Fabricate doors airtight and suitable for duct pressure class.
   2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
   3. Number of Hinges and Locks:
      a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
      b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
      c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches with outside handles.

2.15 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Ductmate Industries, Inc.
   2. Flame Gard, Inc.
   3. 3M.
   4. Approved Equal.

C. Labeled according to UL 1978 by an NRTL.

D. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

E. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

F. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

G. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.16 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. Approved Equal.

C. Materials: Flame-retardant or noncombustible fabrics.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

2.17 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
4. Approved Equal.

C. Noninsulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire.
1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.

D. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.

2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1, 2007.

E. Flexible Duct Connectors:
1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.18 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft and control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire, smoke, combination fire smoke dampers according to UL listing.

H. Connect ducts to duct silencers rigidly.

I. Insulate duct silencers similar to ductwork system served, refer to section 230713.

J. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. On both sides of duct coils.
   2. At outdoor-air intakes and mixed-air plenums.
   3. At drain pans and seals.
   4. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
   5. Adjacent to and close enough to fire, smoke or combination fire smoke dampers, to reset or reinstall fusible links. Access doors for access to fire dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   6. Provide access panels as required to facilitate duct cleaning, per ASHRAE 62.
   7. At each change in direction, at each floor and at maximum 25-foot spacing for grease exhaust ducts.
   8. Upstream from turning vanes.
   9. Upstream or downstream from duct silencers.
   10. Control devices requiring inspection.
   11. Elsewhere as indicated.

K. Install access doors with swing against duct static pressure.

L. Access Door Sizes:
   1. Minimum size: 12x12 inches or as necessary to permit maintenance and cleaning functions

M. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

N. Install flexible connectors to connect ducts to equipment.

O. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

Q. Connect diffusers to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

R. Connect flexible ducts to metal ducts with draw bands.

S. Install duct test holes where required for testing and balancing purposes.

T. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operate dampers to verify full range of movement.
   2. Inspect locations of access doors and verify that purpose of access door can be performed.
   3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
   4. Inspect turning vanes for proper and secure installation.
   5. Operate remote damper operators to verify full range of movement of operator and damper.

End of Section

Section 23 34 16

CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes: For each product.
1. Inline, direct drive, ECM, centrifugal fans

1.3 REFERENCES

A. AMCA 99, "Standards Handbook"

B. ANSI/AMCA Standard 204-96, "Balance Quality and Vibration Levels for Fans"

C. ANSI/AMCA Standard 210-99, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating"

D. AMCA Publication 211-05, "Certified Ratings Programme - Product Rating Manual for Fan Air Performance"

E. AMCA Standard 300-96, "Reverberant Room Method for Sound Testing of Fans"

F. AMCA Publication 311-05, "Certified Ratings Programme - Product Rating Manual For Fan Sound Performance"

G. AMBA - Method of Evaluating Load Ratings of Bearings ANSI-11 (r1999).

H. OSHA guideline 1910.212 - General requirements for Machine Guarding. (www.osha.gov)

I. OSHA guideline 1926.300 - General requirements for safe operation and maintenance of hand and power tools. (www.osha.gov)

J. OSHA guideline 1910.219 - General requirements for guarding safe use of mechanical power transmission apparatus. (www.osha.gov)

K. UL Standard 705, "Power Ventilators"

L. UL Standard 762, "Power Roof Ventilators for Restaurant Exhaust Appliances." All fans not entirely welded shall be UL 762 rated for outdoor use only. Drain connections and access doors shall be provided. All fans UL 762 listed shall be in the upblast orientation.

M. UL Listed as "Power Ventilators for Smoke-control Systems"

1.4 PERFORMANCE REQUIREMENTS

A. AMCA Compliance:
1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
2. Operating Limits: Classify according to AMCA 99.

B. Unusual Service Conditions:
1. Ambient Temperature: 91F.
2. Constant exposure to salt laden air (corrosion resistant coating required).

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.5 ACTION SUBMITTALS

A. Product Data:
1. Include rated capacities, furnished specialties, and accessories for each fan.
2. Certified fan performance curves with system operating conditions indicated.
3. Certified fan sound-power ratings.
4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
5. Material thickness and finishes, including color charts.
6. Dampers, including housings, linkages, and operators.

B. Shop Drawings:
1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set(s) for each belt-driven unit.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for kitchen exhaust shall also comply with UL 762.

1.8 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.10 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Field quality-control reports.

1.11 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.12 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 INLINE, CENTRIFUGAL, DIRECT DRIVE

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Greenheck Fan Corporation –
2. Penn Barry.
3. Loren Cook Company.
4. Or Approved Equal.

B. The fan housing shall be of the square design, constructed of heavy gauge galvanized steel and shall include square duct mounting collars.

C. Fan construction shall include two removable access panels located perpendicular to the motor mounting panel. The access panels must be sufficient size to permit easy access to all interior components.

D. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.

E. Motors shall be permanently lubricated and carefully matched to the fan loads. Motors shall be readily accessible for maintenance.

F. A NEMA 1 disconnect switch shall be provided as standard, except with explosion resistant motors, where disconnects are optional. Factory wiring shall be provided from motor to the handy box.

G. All fans shall bear the AMCA Certified Ratings Seal for both sound and air performance.

H. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification.

I. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside or outside fan housing, factory wired through an internal aluminum conduit.
   a. All disconnect switches installed outdoors shall be provided with a NEMA 4X enclosure
2. Coating: Hi-Pro Polyester
3. Provide with Vari-Green controller with remote dial, to provide 0-10 volt DC signal to Greenheck's Vari-Green (or approved equal) motor
4. Duct Collars:
5. Square design to provide a large discharge area
6. Inlet and discharge collars provide easy duct connection

J. Access Panel:
1. Two sided access panels, permit easy access to all internal components
2. Located perpendicular to the motor mounting panel

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

B. Electronically Commutated Motor
1. Motor enclosures: Open type
2. Motor to be a DC electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors.
3. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
4. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor.
5. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.
6. Motor shall be a minimum of 85% efficient at all speeds.

2.3 Sound data

A. Sound power level data shall be submitted to the mechanical and acoustical engineers for approval. The submitted data shall be based on sound power measurements on similar units. The submittal shall include a complete description of the methods and procedures used to develop the sound power levels being submitted.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting: Install continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support weight of dehumidification unit.
   1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
   2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

E. Install units with clearances for service and maintenance.

F. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Verify lubrication for bearings and other moving parts.
   5. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   6. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
   7. Remove and replace malfunctioning units and retest as specified above.

D. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

End of Section

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Section 23 36 00

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Bypass, single-duct air terminal units.
2. Casing liner.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. LEED Submittals:

1. Provide manufacturers' or third-party certification of testing to and compliance with the California Department of Public Health (CDPH) Standard method v1.2-2017, that includes the following information:
   - The exposure scenario used to determine compliance.
   - The range of total VOCs after 14 days, measured as specified in the CDPH Standard Method v1.2:
     - 0.5 mg/m^3 or less;
     - Between 0.5 and 5.0 mg/m^3; or
     - 5.0 mg/m^3 or more
   - Laboratory accreditation under ISO/IEC 17025.
   - Claims of compliance for wet-applied products must state the amount applied in mass per surface area
2. Provide MSDS or other manufacturer documentation with disclosure of VOC content for all wet-applied products.
3. Complete "LEED Materials Documentation Sheet" with IEQc2 information for adhesives/sealants installed within the waterproofing membrane.

4. Product Data: For adhesives, indicating VOC content.

5. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
6. Product Data: For coatings, indicating VOC content.
7. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.
8. Product Data: For sealants, indicating VOC content.
9. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For air terminal units.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Delegated-Design Submittal:

1. Materials, fabrication, assembly, and spacing of hangers and supports.
2. Include design calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Size and location of initial access modules for acoustic tile.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Instructions for resetting minimum and maximum air volumes.
b. Instructions for adjusting software set points.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan-Powered-Unit Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

A. Acceptable Manufacturers:
1. Titus
2. Price
3. Enviro-tec

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.040-inch thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections, size matching inlet size.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with solid shaft rotating in bearings. and peripheral gasket and self-lubricating bearings.
1. The damper shall incorporate a visual position indicator etched into the end of the damper shaft to clearly indicate damper position range over the full 90 degrees.

2. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure in accordance with ASHREAE 130.

A. Airflow Sensor: Manufacturer's differential pressure sensor shall be cross shaped multi-point center averaging type. Single axis sensor shall not be acceptable for duct diameters 6" or larger. A sensor that delivers the differential pressure signal from one end of the sensor is not acceptable. The sensor shall output an amplified differential pressure signal that is at least 1.5 times the equivalent velocity pressure signal obtained from a conventional pitot tube. Balancing taps and airflow calibration charts shall be provided for field airflow measurements.
   1. The sensor shall be fire-resistant, and compliant with UL 94.
   2. Control tubing shall be protected by grommets at the wall of the airflow sensor's housing.

B. Attenuator Section: 0.034-inch steel sheet.
   1. Length: 3 feet unless otherwise noted on terminal unit schedule.

   2. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
   3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced as required to achieve design output, but no less than 10 fins per inch., and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.
   1. Gasketed coil access door upstream of the coil.
   2. All coils shall be certified in accordance with AHRI 410 and bear the AHRI 410 label.

D. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
   1. ETL listed to UL 1995 and CSA 22.2, and provided by the terminal unit manufacturer.
   2. SCR controlled
   3. Access door with interlocked disconnect switch.
   4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
   5. Nickel chrome 80/20 heating elements.
   6. Airflow switch for proof of airflow.
   7. Fan interlock contacts.
   8. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
   9. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

   10. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.

11. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
12. Disconnect Switch: Factory-mounted, fuse type.
13. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

E. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
1. Pressure independent VAV controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated, to be shipped to terminal unit MFR by controls vendor for factory mounting before shipment. Requirements to be coordinated with ATC vendor.

2.3 CASING LINER

A. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Minimum Thickness: 3/4 inch.

2. Minimum R-value of 3.0.
3. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
4. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

a. Verify adhesive has a VOC content of 80 g/L or less.
b. Verify adhesive complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.2 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." Comply with requirements for seismic-restraint devices in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on air terminal units that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.3 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install the terminal units in accordance with the manufacturer’s instructions.

3.4 CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Install inlets of the air terminal units with minimum three duct diameters of straight length.

D. Provide ceiling access doors for units above hard ceilings.

E. Connect terminal units to ductwork as shown in mechanical details.

F. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

3.5 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553

"Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

End of Section

Section 23 37 13

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Ceiling-integral continuous diffusers (linear).
2. Fixed face registers and grilles.
3. Plaque style supply diffusers

B. Related Sections:

1. Section 089000 "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

1.5 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 REGISTERS AND SQUARE CEILING DIFFUSERS

A. Linear Diffuser (supply, return, exhaust, transfer application) –

1. Subject to compliance with requirements, provide product indicated on schedules in drawings or comparable product by one of the following:

a. Titus FL.
b. Krueger.
c. Price Industries.
d. Or Approved Equal.

2. Provide all materials and equipment required for a complete installation of all linear and modular slot air distribution systems as shown on the architectural and mechanical drawings and/or indicated in the architectural or mechanical specifications. The systems shall be complete in every respect and shall include all required appurtenances. Mechanical contractor shall furnish and install all plenums, hoods, blank-offs and associated sheet metal components including all duct connections thereto.

3. Provide all continuous linear slot and modular slot diffusers as shown on the drawings. The slot diffusers shall integrate into the ceiling system. Where curved linear slot diffusers are indicated, they shall be stretched formed to the exact radii required. Rolled or segmented linear slot diffusers will not be accepted.

4. The linear slot diffusers shall have a single slot unless shown otherwise and shall be capable of being used for supply air, return air, exhaust air or any combination there of.

5. The linear slot diffusers shall be capable of supporting the ceiling system. Linear diffusers supported by screws in the flanges or from air plenums are unacceptable. For lay-in ceiling, provide hanger wire support clips that are integral with the linear slot diffusers allowing the linear slot diffusers to be supported from the building structure with ceiling wire. For hard ceilings, provide clips that are integral with the linear slot diffusers allowing the diffusers to be secured directly to the ceiling framing without the requirement for hanger supports. Provide spline clips to secure joints and ceiling tees to the diffusers.

6. Provide ends and corners as required. Ends shall be butt type, field installed, or mitered picture frame type factory installed, as indicated herein or shown on the drawings. Corners shall be mitered one piece unit.

7. Pattern controllers shall be one piece extruded aluminum, 24 inches long maximum, positioned between spring loaded spacers. Pattern controllers shall allow the airstream to be directed flat against the ceiling in either direction or downward as well as allowing throw reduction every two feet along the entire length of the linear slot diffusers. The airstream shall be maintained at the ceiling plane and shall not dump when volume is reduced. Only extruded aluminum pattern controllers are acceptable. Where shown or noted pattern controllers shall be designed to allow the airstream to be jetted into the occupied space and be adjustable to vector the airstream as required.

8. Material shall be minimum wall thickness 0.062 inches extruded aluminum. Spring steel retainers shall be used under the spacers to hold the slot diffusers assembly tightly together and allow the slot diffusers to be disassembled easily for field trimming. Materials other than extruded aluminum and spring steel will not be accepted.

9. Flanges exposed to view shall be painted factory standard white. All other surfaces shall be painted flat black. Provide paint samples.

10. Model numbers are indicated on the plan schedules.

11. All slot diffusers shall be manufactured by the same manufacturer of the plenums and hoods. No exceptions will be allowed. Plenum lengths and entry collar sizes shall be as indicated on the plan schedules.

12. Plenums shall be minimum 24-gauge galvanized steel and lined inside with black matte fiberglass insulation. Hoods shall be 51 percent free area and constructed of 24-gauge perforated sheet metal painted flat black.

13. Where shown on the drawings or otherwise indicated, provide a friction type volume damper located in the entry collar of the supply air plenum, accessible through the slot diffuser.

14. Air test and balance of linear and modular slot diffusers systems shall be by this section and be in accordance with the testing and balancing portion section of

the specifications. Position all FlowBar pattern controllers in their normal operation positions and perform all air testing and balancing of all slot diffuser systems in full accordance with manufacturer's recommendations.

15. All slot diffusers shall be performance tested with air plenums as a composite assembly in full accordance with ASHRAE, and/or ARI standards. If requested, the contractor shall provide for a visit by the mechanical consulting engineer to the product testing laboratory to verify performance data and testing procedures. All cost associated thereto shall be provided at the expense of the contractor.

16. Diffusers shall be selected to achieve a throw to room length ratio which meets the requirements of the ASHRAE 2001 Fundamentals Handbook, Chapter 32, Table 4, at both maximum design flow rate, and for VAV systems, at the minimum flow rate expected during partial occupancy. Diffusers shall be selected to achieve a minimum of 70 percent ADPI over the range of expected loads in the space. The diffusers' reported performance shall be based on tests conducted in accordance with ASHRAE Standard 70–91. ADPI performance on at least one unit size of the selected diffuser shall have been tested in accordance with ASHRAE Standard 113–90, to validate conformance and applicability to the ASHRAE table.

17. Provide end caps at all active sections of linear diffusers.

18. Comparable products may be submitted as a substitution provided they are in full compliance with all sections of this specification and meet performance requirement. The contractor should note that if the substitution adds costs to any other sections of this specification, or causes the architect and/or engineer to incur redesign costs, the contractor shall be fully responsible for the reimbursement of all these costs.

19. Refer to schedule for throw pattern, high throw, jet throw.

20. Provide light shield at all return, transfer applications.

B. Square Plaque Diffuser –

1. Architectural square panel ceiling diffusers shall be the TITUS Model OMNI (steel) diffuser of the sizes and mounting types shown on the plans and outlet schedule. The OMNI diffuser shall have an 22-gauge steel face panel that captures a secondary 22-gauge panel. The OMNI-AA shall have a heavy gauge aluminum face panel that captures a secondary heavy gauge aluminum panel. The face panel is removable by means of four hanger brackets. The exposed surface of the face panel shall be smooth, flat, and free of visible fasteners.

2. The face panel shall project ¼ inch below the outside border of the diffuser backpan. Panels projecting more than ¼ inch below the outside border are not acceptable. The back of the face panel shall have an aerodynamically shaped, rolled edge to ensure a tight horizontal discharge pattern. A single metal thickness on the edges of the face panel will not be accepted. Ceiling diffusers with a 24 x 24-inch full face shall have no less than an 18 x 18-inch face panel size. Ceiling diffusers with a 12 x 12-inch full face shall have no less than a 9 x 9-inch face panel size.

3. The backpan shall be one piece precision die-stamped and shall include an integrally drawn inlet (welded-in inlets and corner joints are not acceptable). The diffuser backpan shall be constructed of 22-gauge steel (OMNI). The diffuser neck shall have a minimum of 1¼-inch depth available for duct connection.

4. The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes.

5. The pencil hardness must be HB to H.

6. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.

7. Round damper shall be constructed of heavy gauge steel and provided for each diffuser, located as far from diffuser outlet as possible

8. Directional Blow clips shall be available to restrict the discharge air in certain directions.

9. The manufacturer shall provide published performance data for the square panel diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

C. Aluminum louvered grille,

1. Subject to compliance with requirements, provide product indicated on schedules in drawings or comparable product by one of the following:

   a. Titus 350ZFL.
   b. Krueger.
   c. Price Industries.
   d. Or Approved Equal.

2. Aluminum return grilles shall be TITUS Model 350F (¾-inch blade spacing) of the sizes and mounting types shown on the plans and outlet schedule. The fixed deflection blades shall be available parallel to the long or short dimension of the grille. Construction shall be of extruded aluminum with a 1¼-inch wide border on all sides. Minimum border thickness shall be 0.040-0.050 inch. Sizes 24 x 24 inches and smaller shall be constructed using a roll-formed frame.

3. Corners shall be welded with full penetration resistance welds. Sizes larger than 24 x 24 inches shall be constructed by using heavy aluminum extrusions and shall be interlocked at the four corners and mechanically staked to form a rigid frame. Screw holes shall be counter-sunk for a neat appearance.

4. Deflection blades shall be contoured to a specifically designed and tested cross-section to meet published test performance data. Blades shall be firmly held in place by mullions from behind the grille and fixed in place by crimping or welding. Blade deflection angle shall be available at 35°.

5. Opposed blade volume damper shall be constructed of heavy gauge steel or aluminum. Damper must be operable from the face of the grille, where duct mount dampers are not possible.

6. The grille finish shall be selected by Architect. The finish shall be an anodic acrylic paint, baked at 315° F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.

7. The manufacturer shall provide published performance data for the grille. The grille shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

8. Mounting: Concealed screw, Type C.

2.2 Aluminum louvered grille, SG (supply application)

1. Subject to compliance with requirements, provide product indicated on schedules in drawings or comparable product by one of the following:

   a. Titus 300FL.
   b. Krueger.
   c. Price Industries.
   d. Or Approved Equal.

2. Aluminum supply grilles shall be TITUS Model 300FL (double deflection) of the sizes and mounting types shown on the plans and outlet schedule. The deflection blades shall be available parallel to the long dimension of the grille or register. Construction shall be of aluminum with a 1¼-inch wide border on all sides. Sizes 24 x 24 inches and below shall have roll-formed borders with a minimum thickness of 0.032 inch. Larger sizes shall be constructed using continuous aluminum extrusions with a nominal thickness of 0.040 through 0.050 inch and shall be interlocked at the four corners and mechanically staked to form a rigid frame. Screw holes shall be countersunk for a neat appearance.

3. Deflection blades shall be contoured to a specifically designed and tested cross-section to meet published test performance data. Blades shall be spaced on ¾-inch centers. Blades shall have friction pivots on both sides to allow individual blade adjustment without loosening or rattling or be inserted through the frame and held tight with steel friction wire interlocked to the frame on both ends of each side. Plastic blade pivots are not acceptable.

4. The grille finish shall be approved by architect. The finish shall be an anodic acrylic paint, baked at 315° F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.

5. Face Size: Refer to schedule and plans.

6. Duct Inlet: As scheduled

7. Face Style: Flush.

8. Mounting: Concealed screw, Type C.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. For installations in gypsum board ceilings, provide a plaster ring for flush mounting.

D. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

End of Section

Section 23 41 00

PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pleated panel filters.
2. Non-supported bag filters.
3. Side-service housings.
4. Filter gages.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

2. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

3. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.

2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

3. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."

2. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

C. Comply with NFPA 90A and NFPA 90B.

D. All filters shall be UL classified.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

1.8 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 PLEATED PANEL FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Camfil-Farr
   b. Filtration Group
   c. Freudenberg Filter Division / Viledon
   d. Tri-Dim

B. Filter Unit Class: UL 900, Class 2.

C. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

3. Media shall be coated with an antimicrobial agent.

4. Separators shall be bonded to the media to maintain pleat configuration.

5. Welded wire grid shall be on downstream side to maintain pleat.

6. Media shall be bonded to frame to prevent air bypass.

7. Support members on upstream and downstream sides to maintain pleat spacing.

D. Filter-Media Frame: Wet strength cardboard frame with perforated metal retainer or support straps sealed or bonded to the media.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

1. MERV Rating: 8 when tested according to ASHRAE 52.2.

2.2 HIGH PERFORMANCE RIGID POCKET FILTER

A. Description: Factory-fabricated, dry, extended-surface, nonsupported filters with header frames.

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Camfil-Farr
   b. Filtration Group
   c. Freudenberg Filter Division / Viledon
   d. Tri-Dim

B. Filter Unit Class: UL 900, Class 2.

C. Filters shall be high capacity depth-loading rigid pocket filters.

D. Filters shall be available in 18" and 26" pocket depth.

E. Filters shall be the Viledon T-60 and MF-70 products, or approved equals.

F. This type of filter is employed as primary filtration, MERV 13.

G. Filter frame shall be high-impact plastic.

H. The filter media shall be manufactured from three distinct layers of organic synthetic fibers and microfibers. The pre-filter layer shall be thermally bonded to prevent fiber shedding and break-off. The micro-fiber layer shall be constructed from synthetic microfibers. Filters containing either urea-extended phenolformaldehyde binders, air-laid microfiberglass, or cotton fibers are not acceptable. The filter media shall be progressively structured to enhance depth loading and to provide lower average static resistance and longer life.

I. The filter media shall be hydrophobic and operate unaffected at relative humidity up to 100% and completely impervious to mechanical (handling) damage.

J. The filter pockets shall be injection molded into a hard polyurethane header to ensure a leak-proof seal. Pockets that are crimped into metal headers are not acceptable.

K. Filter must be supplied with factory-applied closed-cell neoprene gasketing as required for each application (either side-load gasket or down-stream gasket) to prevent air leakage and bypass. Open-cell foam is unacceptable.

L. Pockets shall be self-supporting.

M. The filter shall be fully tested in accordance with the ASHRAE 52.2-2007 Test Standard, and have a MERV Rating and Pressure drop as listed in the following table:

Filter Efficiency	Airflow Velocity	Initial Pressure Drop
MERV 13	500 fpm	0.23" w.g.

N. The filter shall have a documented wet burst strength of no less than 12" w.g.

2.3 SIDE-SERVICE HOUSINGS

A. Description: Factory-assembled, side-service housings, constructed of galvanized steel with flanges to connect to duct or casing system.

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Camfil-Farr
   b. Filtration Group
   c. Freudenberg Filter Division / Viledon
   d. Tri-Dim

B. Prefilters: Integral tracks to accommodate 2-inch- deep, disposable filters.

C. Access Doors: Hinged, with continuous gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.

D. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

2.4 FILTER GAGES

A. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Airguard.
   b. Dwyer Instruments, Inc.
   c. Or Approved Equal.

2. Diameter: 4-1/2 inches.

3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg or Less: 0- to 1.0-inch wg.

B. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gage for each filter bank.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

E. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling-unit installations.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Operate automatic roll filters to demonstrate compliance with requirements.

2. Test for leakage of unfiltered air while system is operating.

D. Air filter will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

End of Section

Section 23 57 00

HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes gasketed-plate heat exchangers.

1.3 DEFINITIONS

A. TEMA: Tubular Exchanger Manufacturers Association.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
2. Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment.

C. Delegated-Design Submittal: Details and design calculations for seismic restraints for heat exchangers.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room plan or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for heat exchanger, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Heat Exchanger: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of heat exchanger anchorage devices on which certification is based and their installation requirements.

C. Product Certificates: For each type of shell-and-tube heat exchanger. Documentation that shell-and-tube heat exchangers comply with "TEMA Standards."

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of heat exchangers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures, including heat exchanger, storage tank, and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Plate Heat Exchangers:
1) Gasketed-Plate Type; One year(s).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic restraints for heat exchangers.

B. Seismic Performance: Heat exchangers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor is 1.5.

2.2 GASKETED-PLATE HEAT EXCHANGERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Alfa Laval Inc.
2. Armstrong Fluid Technology.
3. Bell & Gossett; a Xylem brand.
4. Taco Comfort Solutions, Inc.
5. Weil-McLain.
6. Wessels Company.

B. Configuration: Freestanding assembly, consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets. Floor-mounted heat exchangers must have integral legs with mounting feet.

C. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

D. Frame:

1. Capacity to accommodate 20 percent additional plates.
2. Painted carbon steel with provisions for anchoring to support.

E. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.

1. Fabricate attachment of heat-exchanger support bars and guide bars with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger support bars and guide bars are anchored to building structure.

F. End-Plate Material: Painted carbon steel.

G. Tie Rods and Nuts: Steel or stainless steel.

H. Plate Material: 0.024 thick before stamping; Type 316 stainless steel.

I. Gasket Materials: Nitrile rubber.

1. Glue: Chlorine free.

J. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.

1. NPS 2 and Smaller: Threaded ends in accordance with ASME B1.20.1.
2. NPS 2-1/2 and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.

K. Enclose plates in solid aluminum or stainless steel removable shroud.

2.3 ACCESSORIES

A. Pressure-Relief Valves: Cast iron,, ASME rated and stamped.

1. Pressure-relief valve setting: 135 **psig**.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect heat exchangers in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1. Affix ASME International label.

B. Hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Heat exchangers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

B. Examine roughing-in for heat-exchanger piping to verify actual locations of piping connections before equipment installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HEAT EXCHANGER, GENERAL

A. Equipment Mounting:

1. Install floor-mounted heat exchangers on cast-in-place concrete equipment bases. Install all heat exchangers level and plumb in accordance with manufacturer's recommendations. Install floor-mounted and wall-hung steam heat exchangers at sufficient height, using sufficient length supports, to achieve

required steam and condensate pipe pitch. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Maintain manufacturer's recommended clearances for tube removal, service, and maintenance.

C. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.

D. Install shutoff valves at heat-exchanger inlet and outlet connections.

E. Install pressure-relief valves on heat-exchanger shells where a connection has been provided on shell. When no shell pressure-relief valve connection has been provided, install pressure-relief valve on shell outlet piping before any isolation valves.

F. Install pressure-relief valves on heat-exchanger tube outlet piping before any isolation valves.

G. Pipe pressure-relief valves, full size of valve connection, to floor drain.

H. Install vacuum breaker at heat-exchanger steam inlet connection.

I. Install hose end valve to drain shell.

J. Install thermometer on each heat-exchanger fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 230519 "Meters and Gages for HVAC Piping."

K. Install pressure gauges on each heat-exchanger fluid inlet and outlet piping. Comply with requirements for pressure gauges specified in Section 230519 "Meters and Gauges for HVAC Piping."

3.4 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. Isolate heat exchangers from piping before flushing piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blind flanges in flanged joints to isolate equipment.

C. Flush heat-exchanger piping systems with clean water; then remove and clean or replace strainer screens before reopening flow to heat exchangers.

3.5 FIELD QUALITY CONTROL

A. Testing Agency, Owner: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency, Contractor: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative:

E. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Heat exchanger will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers.

End of Section

Section 23 73 13.19

CUSTOM, INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Custom variable-air-volume indoor central station energy recovery air-handling units.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of L/200 where "L" is the unsupported span length within completed casings.

1.4 ACTION SUBMITTALS

A. Product Data: For each air-handling unit indicated.

1. Unit dimensions and weight to include dimensioned plans, elevations, and details including motor starter and control cabinets required clearances and location of all field connections and shipping splits.

2. Cabinet material, metal thickness, finishes, insulation, and accessories.

3. Electrical requirements for power supply including wiring diagrams for interlock and control wiring, clearly indicating factory installed and field installed wiring.

4. Sound power level data for the fan unit outlet, inlet and casing radiated at rated capacity and specified pressure.

5. Fans:

    a. Certified fan-performance curves with system operating conditions indicated.
    b. Certified fan-sound power ratings.
    c. Fan construction and accessories.
    d. Motor ratings, electrical characteristics, and motor accessories.

6. Certified coil-performance ratings with system operating conditions indicated.

7. Dampers, including housings, linkages, and operators.

8. Filters with performance characteristics.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Delegated-Design Submittal: For vibration isolation indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

2. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.

2. Support location, type, and weight.

3. Field measurements.

B. Source quality-control reports.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) for each air-handling unit.
2. Gaskets: One set(s) for each access door.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

E. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Comply with NFPA 70.

G. Conform to all information documented in approved submittal package and construction notes.

H. Fan vibration test results shall be available for review prior to any air handling unit shipment to the jobsite.

I. Manufacturer shall have a documented quality assurance plan for providing consistent product quality. The quality assurance plan shall include component quality check lists, random product inspections, fan balance reports, coil and piping leak test reports, electrical system test reports, etc. Copies of these reports shall be made available to the engineer upon request

J. The manufacturer shall perform an air performance test on one selected unit in accordance to AMCA 210-85/ANSI 51-1985 “Standard for Laboratory Measurement of

Airflow". Air handling unit air performance data shall be submitted for review by the Owner's representative.

K. The manufacturer shall perform a sound test on one selected AHU/ERV/MAU in accordance with AMCA Standard 300-96, Reverberant Room Method for sound testing of fans, and AMCA Standard 210, Laboratory Methods of Testing Fans for rating. The mechanical engineer shall select the test AHU/ERV/MAU after review of the submittal.

L. An air handling unit air leakage and panel deflection test shall be performed and the data submitted for review by the Owner's representative.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Ventrol as the basis-of-design or comparable product by one of the following:

1. Air Enterprises
2. Buffalo
3. Environmental Air Solutions (EAS)
4. HAAKON
5. MAFNA
6. Temtrol
7. TMI Climate Solutions
8. Trane Custom
9. Approved equal

B. All construction specifications, including thermal break design, air leakage rate, capacities and performance criteria are met. Unit performance and electrical characteristics shall be per the job schedule.

C. Configuration: Fabricate as detailed on prints and drawings.

D. Furnish and install where shown on the plans, welded frame air handling units with construction features as specified below. The units shall be provided and installed in strict accordance with the specifications. All units shall be complete with all components and accessories as specified. Any exceptions must be clearly defined. The contractor shall be responsible for any additional expenses that may occur due to any exception made

E. Units shall conform to bi-national standard ANSI/UL Standard 1995/CSA Standard C22.2 No. 236. Unit fans and coils shall be ARI certified.

F. The unit shall undergo a complete factory run test prior to shipment. The factory test shall include final balancing of all fan assemblies, and a final unit inspection.

G. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.

H. Performance: All scheduled capacities and face areas are the minimum accepted value. All scheduled amps, KW, and HP are maximum accepted values that allow scheduled capacity to be met.

I. If units are built outside the USA, list country of origin on bid.

2.2 Factory Testing

A. Factory testing shall be done on each typical assembled unit. An owner's representative shall witness the test. Manufacturer to provide for expenses of one owner representative to witness the test, with a two weeks notice.

B. Casing Leakage Test:

1. Housing shall be designed and tested in accordance with the procedures outlined in the SMACNA HVAC Air Duct Leakage Manual to meet a maximum leakage rate of less than 0.5% when tested at 1.5 times the design static pressure.

2. Leak testing is performed by measuring the airflow pumped in or out of the airside portion of the unit at various static pressures. A chambered nozzle with a variable supply system, as described in AMCA STANDARD 210-85, is used as the airflow measurement system.

3. Positive pressure Supply fan discharge opening and all supply air openings are sealed. The airflow measurement system is ducted to the unit and flow measured at various static pressures, up to specified static pressure.

4. Negative pressure Supply fan discharge opening and all return air and other openings are sealed. The airflow measurement system is ducted to the unit and flow measured at various static pressures, up to specified static pressure.

5. The pressure drop across the chambered nozzle in the airflow measurement system is measured with a manometer. The airflow is then calculated using the AMCA STANDARD 210 equations 9.3.2 FLOW RATE FOR CHAMBER NOZZLES. Leakage at the specified static pressure is then calculated from the data taken.

C. Airflow and Static Capability Test:

1. The unit is started-up and operated at full capacity. Pressures external to the unit shall be simulated using a duct and damper combination. Fan system effects, which cannot be measured during the test but have been estimated, will be added to the actual static pressure measured when applicable. The total shall equal the total design static pressure.

2. Airflow is measured with an Air Monitor Corporation – FAN-Evaluator (50”x72”) airflow measuring station in a straight length of duct. The duct length is defined by AMCA 203-90 to establish a uniform velocity profile. Airflow is calculated from the velocity pressure readings of the probes and corrected for the current air density. A “Veltron” airflow measuring station is used to take direct readings. All calculations are per AMCA 210-85. Air volume and discharge static test shall verify that the air volume is within the range of 100% and 110% of the scheduled nominal CFM requirements when operating at design total static pressure.

D. Panel Deflection Test:

1. The panel deflection is measured on the cabinet exterior wall, typically in conjunction with an airflow or leakage test. Prior to pressurization of the unit, a measuring dial is placed on a unit panel and a first reading is taken. The unit is then pressurized to the specified static pressure. A second reading is taken on the dial and the deflection is calculated by dividing by the panel span.

2. Cabinet deflection shall not exceed 1/180 of the panel length on 2” wall units. A written test report shall be prepared by the manufacturer and issued to the Owner’s representative.

E. ERV Factory Fan Vibration Test:

1. Balancing and vibration tests are performed after the fan and motor have been assembled on their isolators. Fan balance report from the fan manufacture is neither equal nor acceptable.

2. FANWALL
   a. Accelerometers are placed on the inboard and outboard motor bearings in 3 planes: X, Y, Z. The fan is run and vibration measurements are taken in all 3 planes with an UltraSpec Dynamic Balance Analyzer Model 8117.
   b. Measurements are taken in velocity (inch per second RMS). By adding small weights on the fan blades, the fan is balanced. Iterations of the previous step are performed until the RMS vibration velocity is below 0.022 in/s. ANSI/AMCA 204 is also used in reference.
   c. The report shall show the final results of balancing with the analyzer’s filter tuned to the speed of the fan.

3. All other fans
   a. Accelerometers are placed on the 2 fan bearings in 3 planes: X, Y, Z. The fan is run and vibration measurements are taken in all 3 planes with an UltraSpec Dynamic Balance Analyzer Model 8117.
   b. Measurements are taken in mils (1/1000th of inch). By adding small weights on the fan blades, the fan is balanced. Iterations of the previous

step are performed until the Peak to Peak vibration displacement is below 1.5 mils. ANSI/AMCA 204 is also used in reference.

c. The report shall show a full spectral analysis of the measured vibrations, expressed in inches per second (RMS).

F. ERV Factory Sound Pressure Test:

1. Site description:
   a. Sound tests shall be conducted while the unit is running at design conditions. Sitting in the middle of an unobstructed bay (55 feet wide) in a large factory space (400 x 300 feet approximately) with a ceiling height of 28 feet. Floor is concrete, ceiling is steel deck over metal trusses, and walls are concrete blocks.

2. Measurements conditions:
   a. Tests shall be conducted while all work is stopped and all unnecessary noises eliminated, resulting in a background noise level lower than 50 dBA and unit noise measurements being at least 10 dB above.

3. Description of measurements:
   a. Sound pressure level (Lp) (in dB, ref. 20 µPa) readings in all nine octave bands (31.5 to 8000 Hz) at feet from designated openings and 5 feet adjacent to fan sections outside of the unit casing.
   b. Calibration check of sound Level meter will be done before and after measurement test. Microphone shall be at 5 feet from floor or horizontal surface and away from direct air turbulence.
   c. All measurements will be monitored to exclude any undesirable noises that are not from the unit. (Ex. Airplane, siren noise, etc.)

4. Report:
   a. Report shall show the measurements and a sketch showing the general arrangement of the test set up. (Points of measurement, distances etc.)

5. Measurement parameters: (Produced by sound level meter application software) showing time, date and sound level meter setting.

G. ERV Sound Analysis

1. Sound analysis consisting of inlet, outlet and radiated sound power levels performed by an AMCA 300 dual reverberant chamber accredited lab. Sound analysis from a non-AMCA accredited lab will not be accepted.

2.3 QUALIFICATIONS

A. The air handling unit manufacturer must have ten years documented prior successful experience in building products meeting the specification and on projects of similar size, scope and complexity.

2.4 GENERAL

A. Provide factory-fabricated air handling units with capacity as indicated on the schedule. Units shall have overall dimensions as indicated and fit into the space available with adequate clearance for service as determined by the Engineer. All units shall come completely assembled. Multiple sectioned units shall be shipped as a single factory assembled piece (except where shipping limitations prevent) de-mounted into modular sections in the field by the contractor. Units shall be furnished with sufficient gasket and bolts for reassembly in the field by the contractor. Unit manufacturer shall provide certified ratings conforming to the latest edition of AMCA 210, 310, 500 and ARI 410. All electrical components and assemblies shall comply with NEMA standards. Unit internal insulation must have a flame spread rating not over 25 and smoke developed rating no higher than 50 complying with NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems." Units shall comply with NFPA 70, "National Electrical Code," as applicable for installation and electrical connections of ancillary electrical components of air handling units. Units shall be UL or ETL listed.

B. General: This specification covers the performance requirements and the material/construction requirements of custom-built air handling units. The detailed performance and data sheets and/or equipment schedule drawing(s) are considered part of this specification.

C. Warranty: The manufacturer shall provide the parts warranty for equipment manufactured and all vendor supplied components. The said warranty shall cover replacement of all defective parts for a period of 12 months from equipment start up.

D. Submittal: The successful manufacturer shall provide Shop drawings and submittal data for review. The submittals and shop drawings shall be complete in all respects including the following information:

1. Overall unit dimensions and individual components and section dimensions
2. Sound analysis consisting of inlet, outlet and radiated sound power levels per unit performed by an AMCA 300 accredited lab.
3. Shipping and operating weight of unit and/or sections.
4. Materials of construction.
5. Cross section details of typical wall, floor and roof construction.
6. Component equipment data as detailed in component specification section.
7. Unit performance data including sound data.
8. Details of coil support in a coil bank.
9. Piping connection sizes and approximate locations.
10. Door and window sizes and elevations.
11. Drain pan details.
12. Operating and Maintenance Data

E. Product Delivery, Storage and Handling

1. All equipment shall be delivered to the job site suitably packaged and protected for overland trucking using heavy-duty protective shrink-wrap plastic. Where multiple units are required, a schedule of priority will be furnished which shall determine the manufacturing and delivery sequence. In general, units shall be delivered in one piece unless indicated otherwise. Where building constraints,

unit size or trucking limitations require that units ship in more than one piece, the manufacturer shall indicate all split points on the shop drawings. All items shipped loose such as filters, steam humidifier assemblies, caulking, etc. shall be itemized on the packing slip and be suitably secured in the unit or on a separate pallet.

F. General Design Considerations

1. Coils shall be arranged so that space between coils is a minimum of 24", unless specifically shown otherwise on drawings. Fan compartment shall be arranged such that the space between the fan inlet(s) and the housing is a minimum of 75% of fan diameter, unless noted or shown otherwise on the schedule or drawings. Coil assembly shall have provisions to facilitate total or partial removal from coil bank. Housing shall be designed and sealed to minimize air and water vapor leakage. Housing shall be designed and tested per the SMACNA HVAC Air Duct Leakage Manual to meet a maximum leakage rate of less than 0.5% when tested at 1.5 times the design static pressure. leakage rate of less than 0.5% when tested at 1.5 times the design static pressure.

G. Unit Base / Floor / Frame Work:

1. The unit base frame is manufactured with a electrostatic pre-primed powder coated epoxy bases 8-ga galvanized steel rectangular structural steel tubing and fitted with 16" on-center C-channel cross support members. The unit base assembly is coated with a second epoxy primer coat and painted with polyurethane paint. The completed unit base coating must be able to sustain salt spray testing of 1000 hours, per ASTM 117B. Sheet metal formed unit bases are not acceptable. The "Double Bottom" base features a 4.5" thick insulated walk-on floor as specified below. The base rails are fitted with welded lifting lugs at the unit or module (if demounted) corners. Bolted sheet metal lifting lugs are not acceptable. Floor liner shall be 16-ga, G-90 galvanized steel. Floor seams hall be sealed to create leak free joints. The perimeter of the unit consists of a 2" continuously welded upturned perimeter lip to create a drainable floor. The under floor liner shall be 10-ga, G-90 stainless steel or 3/16-in aluminum and recessed nominal ½" to allow for air circulation under the unit floor. All floor openings on outdoor units are complete with floor grating. The entire unit base must be closed cell polyisocyanurate foamed in place with a minimum thickness of 3" and a minimum R value of 20. Fiberglass insulated unit bases will not be acceptable. Maximum deflection of floor shall be L/360 at design loading (L=span in inches), the minimum floor design load is 150 lbs/sqft (distributed load), and the maximum point load on floor shall be 300 lbs (over 1 square foot).

H. Panel structural strength:

1. Maximum deflection of walls and roof shall be L/180 at +/- 8" w.c. for 2" construction (L= span in inches) at unit operating pressure. Deflection is worst case at the center of panel.

   a. Minimum roof and wall load is 75 lbs /sqft (distributed load such as wind and snow)
   b. Maximum point load on roof shall be 300 lbs (over 1 square foot)

I. Cabinet Insulation:

1. Closed cell polyisocyanurate foam insulation, minimum R-12 and a noise reduction coefficient (NRC) of 0.70 per inch thick (based on a type ‘‘A’’ mounting). Coefficient meets or exceeds a 3.0 P.C.F. density material rating. The insulation meets erosion requirement of UL 181 facing the air stream and fire hazard classification of 25/50 per ASTM-84 and UL 723, CAN/ULC S102-M88).

J. Cabinet – Smooth Exterior Panels:

1. Formed and reinforced wall panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed. Outside Casing shall be solid 16-ga, Bright spangled G-90 galvanized steel, double die-formed 2” thick panel secured with 1/4” hex head, zinc plated fasteners at 12” on-centers.

2. The inside liner shall be 16-ga galvanized steel and incorporate a 5 degree bend on all exposed surfaces to eliminate any waving. Liner shall be secured with sheet metal screws to outside casing at 12” on-centers. Perforated inner walls are acceptable for use in all sections except in outside air intake, cooling coil.

3. The air handling unit casing shall be of the gasket thermal break design. The casing structure shall incorporate insulating thermal breaks as required so that, when fully assembled, there exists no path of continuous unbroken metal to metal conduction from inner to outer surfaces

4. Under normal internal operating design conditions, there shall be no condensation on the unit exterior at the following ambient conditions:

   a. Indoor units 105°F DB, 80°F WB

5. Finish: All units must be painted using pre-painted galvanized steel comprised of a two coat baked on paint system. Metal is pretreated with microcrystalline zinc phosphate enhancing corrosion resistance and then primed and coated with a durable textured polyester coating. The complete coating must be able to sustain salt spray of 1000 hours, per ASTM 117B. Manufacturer shall confirm that paint system will meet the specification and provide test results.

6. Provide factory penetration of ERV at filter bank(s) for FM compliance. Coordinate location and size with fire protection contractor prior to release of unit for construction. Seal penetration in field.

K. Drain Pans and Cooling Coil Support Structure

1. Condensate Drain Pans are IAQ design, 18-ga., 304 stainless steel and incorporate a double slope shape to eliminate standing water. All drain pans have a “Double Bottom” attached to welded structural steel base, with a minimum of 2” of insulation under the drain pan. Drain connections are standard stainless steel 1-1/4” MPT connection. All coils are self supported to reduce unit height to a minimum. All coils shall be mounted on raised supports above drain pan to facilitate cleaning and coil removal. Coils shall have independent removable access panels on both sides of the coil to allow for coil pull.

a. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
b. Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
c. Depth: A minimum of 2 inches deep.
d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan. Minimum Connection Size: NPS 2DN.
e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
f. Drain pans shall be insulated minimum 3 inch “Double Bottom" construction with welded corners.

L. Access doors and panels:

1. Access doors are constructed with a double wall construction and an extruded aluminum frame. The doorframe features a built-in no-through-metal high density resin barrier and a perimeter gasket. Door frames with no thermal break are not acceptable. The door gasket is seamed together at each corner to prevent leakage trough the door. Door is attached to the unit with 3 axes adjustable stainless steel hinges. Doors shall open against higher pressure side. Where this is not feasible due to site constraints, an interlocking mechanism furnished on the fan section access door with a de-energizing switch complying with CAL-OSHA, ETL and the mechanical protection requirements of UL 1995 will be provided.

2. Inspection access panels and doors shall be sized and located to allow periodic maintenance and inspections. Provide access panels and doors in the following locations as shown on drawings

3. Dual-paned tempered glass with vacuum seal windows with thermally broken fames shall be supplied as shown on unit drawings. Singled paned windows with desiccant bag are not acceptable.

4. All outward swinging doors must be equipped with a door chain to limit door swing.

M. Fans

1. Fans shall be aluminum airfoil, Class III, direct drive arrangement and shall be individually housed. Fans shall be certified by AMCA for performance. Fan shall be housed in a “cell”. Class I and Class II fans are not acceptable.

2. Fan housing or “cell” shall be constructed of aluminum or stainless steel with perforated inner liner, melamine insulation, with either solid or perforated outer panels as required by application.

3. Fan/motor assembly shall be mounted within the housing on an adjustable slide rail base. Fan/motor assembly must be capable of either horizontal or vertical application.

4. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, for fan application class BV-5, to meet or exceed a rotational imbalance Grade G.55, producing a maximum rotational imbalance of .022" per second peak, filter in (.55mm per second peak, filter in). "Filter in" measurement indicates that the specified balance grade must be achieved at the submitted design operating speed for the fan(s). Fan and motor assemblies submitted for approval incorporating larger than 215T frame shall be balanced in three orthogonal planes to demonstrate compliance with the G.55 requirement with a maximum rotational imbalance of .022" per second peak filter in (.55 mm per second peak, filter in).

5. Fan and motor assemblies shall be designed for application in multiple fan arrays.

N. Motors

1. All motors shall be standard foot mounted type, TEAO motors selected at the specified operating voltage, RPM, and efficiency as specified or as scheduled elsewhere.

2. Motors shall meet the requirements of NEMA MG-1 Part 30 and 31, section 4.4.2.

3. Motors shall be as manufactured by Baldor, GE, Marathon, or approved equal. Motors shall be available in 1/2 HP increments at nameplate HP ratings from 1.5 HP through 12 HP.

4. Acceptable VFD's are to be manufactured by ABB, Yaskawa, Eaton/Cutler Hammer or approved equal. See VFD section 232923 for additional details.

5. All motors shall include permanently sealed bearings and AEGIS SGR shaft grounding rings to protect the motor bearings from electrical discharge machining due to stray shaft current. Motors shall be provided with hybrid ceramic bearings, and do not require shaft grounding devices.

6. Steel cased motors and/or ODP motors are not acceptable.

O. Acoustical Performance

1. The AHU/ERV/MAU unit shall provide the specified acoustical performance as scheduled for the unit supply discharge opening(s), RA opening(s), and the Outside air and Exhaust air opening(s).

2. Coplanar silencer(s) and/or sound attenuator(s) shall be provided to meet specified acoustical requirements. Sound attenuator cross sectional area shall be selected to not exceed 500 fpm. Losses from sound attenuating devices must be included in the fan performance selection.

3. Listed or alternate manufacturers, other than the basis of design, providing fan arrays that incorporate fans which are not manufactured by the AHU/ERV /MAU manufacturer, must provide modeled acoustical performance of the AHU/ERV/MAU unit.

4. Sound and performance data for approval showing only single fan performance for multiple fan array application will be returned without review.

5. Any proposed remedy for deviations in submitted sound power levels shall be approved by a registered acoustical consultant as selected by the owner or architect. Costs for review of proposed changes shall be borne by the contractor.

P. Multiple Fan Arrays

1. Each fan and motor assembly shall be removable through a 24” wide, free area, access door located on the discharge side of the fan wall array without removing the fan wheel from the motor.

2. All fans in the multiple fan arrays shall be AMCA certified for performance per AMCA arrangement “A” testing configuration. The submitted fan performance shall be inclusive of system effects attributed to the fan mounting arrangement, fan enclosures, back draft dampers, and other fan appurtenances not considered when AMCA certified performance per AMCA arr. “A” is determined. Submitted AHU/ERV/MAU fan performance that does not indicate allowances for system effects for the back flow prevention device(s), wheel enclosures, safety screens, bearing pedestals, belt guards, or the fan and motor enclosure in which each fan is mounted, will be returned to the contractor disapproved and will need to be resubmitted with all of the requested information included for approval. Added system effects for acoustic attenuators, or other devices required to meet specified fan performance and sound levels must be indicated in the submitted fan selection data.

3. Fan system power requirements or sound power levels that fail to meet specified performance levels shall be corrected to meet specified performance levels at no additional cost to the owner. Any proposed corrections for power or sound deviations from specified values must be submitted to the engineer for approval prior to implementation of any proposed corrective procedure.

4. Submittals for units providing less than the scheduled quantity of fans and/or spacing of the fans for multiple fan arrays shall submit CFD modeling of the air flow profile for approval that indicates uniform velocity and flow across all internal components without increasing the length of the ERV unit or changing the aspect ratio of the unit casing as designed.

Q. Backdraft dampers:

1. Each fan applied in multiple fan applications shall be provided with an integral back flow prevention device that prohibits recirculation of air in the event a fan, or multiple fans, becomes disabled. The system effect for the submitted back flow prevention device shall be included in the calculation to determine the fan TSP for fan selection purposes, and shall be indicated as a separate line item SP loss in the submitted fan selection data. Manufacturers other than the basis of design being submitted must provide independent lab certification of fan testing that indicates the system effects attributed to the submitted back flow prevention device in the submitted close coupled mounting arrangement at the inlet of the fan. Fans submitted with discharge dampers will not be approved.

2. Back Draft Damper performance data that is based on an AMCA ducted inlet and ducted discharge mounting configuration will not be accepted. Submitted Back flow prevention device data must be reflective of close coupled mounting at the intake of the fan(s) per the project design documents. Motorized dampers or other motorized devices submitted for back flow prevention are not acceptable.

3. ERV Manufacturers that do not manufacture the fans being submitted must provide tested and certified performance data for fans as installed in the ERV unit including the back draft damper system effects introduced by close coupled back draft dampers at the fan inlet.

R. Fan Airflow Monitoring

1. All Fans shall have noninvasive, zero pressure drop flow a/o pressure sensing taps installed in the fan inlet cone and include airflow monitoring capability.

S. Control Panel

1. Each fan motor shall be individually wired to a motor control panel containing motor overloads and VFD(s). VFD configuration shall be:
   a. Each motor having its own VFD

2. Each unit shall have a single point electrical power connections.

3. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards and local code requirements.

T. Redundancy in the variable frequency drives shall be included, along with all necessary controls and devices to assure that in a fault condition for any drive, whether internal or external to the drive, the fan array shall maintain flow and pressure at the required fan operating speed at the time of the fault with no interruption in flow to the system affected

2.5 Coils

A. Type "WC" Chilled or Hot Water Coils

1. Primary Tube Surface
   a. Round seamless 5/8" O.D. copper tubes with 0.035" wall thickness mechanically expanded into fin collars of the secondary surface. Tubes shall be mechanically expanded to provide a permanent metal-to-metal bond for efficient heat transfer. Manufacturer may only use staggered tubes in direction of airflow and only return bends - reduced tube wall hairpin bends are not acceptable. 10 rows maximum.

2. Secondary Fin Surface
   a. Die-formed, corrugated plate-type 0.008" Aluminum fins with full drawing fin collars to provide accurate fin spacing control and maximum tube contact. 12 fins per inch maximum.

3. Headers
   a. Seamless copper with die-formed holes to provide a parallel surface to the coil tube for strong brazing joints. Coil is supplied with 1/8" brass female pipe thread (FPT) vents and drains. All circuiting is designed to gravity-drain.

4. Connections
   a. Red Brass Schedule 40 male pipe thread (MPT) to prevent dielectric reaction between dissimilar metals.

5. Casing
   a. Minimum 16 ga. 304 Stainless Steel with 1-1/2" die-formed flanges to permit easy stacking and mounting. Intermediate tube supports are supplied on coils over 44" fin length with additional supports every 42" multiple thereafter.

6. Testing and Performance
   a. All coil assemblies are leak tested under water at 500 PSIG. Standard construction is suitable for 250 PSIG operating pressure up to 300° F. PERFORMANCE is CERTIFIED under ARI Standard 410. All coil performance ratings are generated with manufacturer's ARI certified selection software.

7. Applied fixtures/lamps must be specifically manufactured for this purpose. Safety interlocks/features shall be provided to limit hazard to operating staff.

8. Provide removable panels on both sides of the all coils.

2.6 Filters, Filter Frames, and Filter Banks

A. Provide filters of the type indicated on the schedule. Factory fabricated filter sections shall be of the same construction and finish as the unit. Face loaded pre and final filters shall have Type 8 frames as manufactured by AAF, FARR or equal. Internal blank-offs shall be provided by the air unit manufacturer as required to prevent air bypass around the filters. The filters shall be as manufactured by Farr, Purolator, AAF or equal. Filters shall be in compliance with ANSI/UL 900 – Test Performance of Air Filters.

B. Filter Gage: Each Filter bank shall be furnished with: Magnehelic filter gage Air filter gage, inclined manometer. 4-in diameter, diaphragm-actuated dial in metal case, with Vent valves, Black figures on white background, Front recalibration adjustment, 2 percent of full-scale accuracy.

C. Range: 0- to 2.5-inch wg.

D. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch aluminum tubing, and 2- or 3-way vent valves.

E. Comply with NFPA 90A.

F. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

G. Provide filter holding frames constructed of galvanized steel arranged for flat or angular orientation, with access doors. Filters shall be removable from upstream.

H. Air filtration is specified in Division 23 section “Particulate Air Filtration”.

I. Prefilters

1. The filter shall consist of a pleated media, media support grid, and enclosing frame. The filters shall be labeled by Underwriters Laboratories as Class 2. The media shall be non-woven cotton fabric and shall have a minimum efficiency (ASHRAE test standard 52-76) of 30% with minimum arrestance of 90%, MERV 8. The media support shall be a welded wire grid with an effective open area of not less than 90%. The grid shall be bonded to the filter media to eliminate media oscillation and pull away. The enclosing frame shall be constructed of rigid, heavy duty, high wet strength beverage board. The frame shall be bonded to the filter pack. Standard sizes shall be 12" x 24" x 2" and 24" x 24" x 2". All filter holding frames must be caulked in between them to minimize bypass air through the frames.

2.7 DAMPERS

A. Aluminum dampers with a maximum leakage of 4 cmf/sf at 1.0-in of water as made by TAMCO 1000. Dampers are made of extruded aluminum airfoil blades with extruded EPDM blade gaskets and extruded TPE frame seals, 7/16’’ aluminum hexagon shaft, aluminum linkage crankarm, aluminum pivot pin, acetal copolymer inner bearing and polycarbonate outer, and a 12-ga. aluminum frame.

1. Outdoor air applications shall be provided with TAMCO SW (saltwater), or approved equal, construction features.

B. Provide dampers capable of direct coupled linkage.

2.8 Energy Recovery Wheel (Thermotech TF Series, or approved equal):

A. The structural frame and casing shall be designed and manufactured so as to allow a maximum rotor deflection of 1/32 inch, as measured at the outer radius, during maximum rated airflow condition.

B. All sheet metal shall be reinforced as required to provide a solid mounting surface of the peripheral and radial seals in order to maintain a minimum of ¾ inch fixed distance between the rotor surface and any sheet metal or steel parts. There shall be no special requirement to provide any casing side access for future rotor removal and/or service. All such service work shall be possible to perform from inside the duct at the face of the rotor casing.

C. External tapered roller bearings with double set screw locking collars shall be provided and sized for a minimum L-10 life of 1,000,000 hours of operation and shall be changeable without a complete disassembly of the rotor. Shaft journals shall be machined to proper tolerance as specified by the bearing manufacturer. Shaft shall be machined as to provide a shoulder against the bearings for a positive locked position to eliminate any lateral movement of the rotor due to axial bearing loads. Grease fittings shall be easily accessible.

D. The spokes shall be made of extruded aluminum with an "I" beam shape to limit deflection of the rotor to 1/32 inch for the maximum rated airflow. Spoke surfaces to be serrated for increased friction and air turbulence across the seals.

E. The rim joint shall connect the spoke ends and the rim ends together in such a way that the heat transfer media can be installed under field conditions without any media deformation or misfits causing future problems. The rim joints shall provide a gradual compression of each section by independently applying increased tension of the rim bolts without the use of any special tools or devices.

F. The rims shall be made of two extruded aluminum sections -- one inner rim and one outer rim with grooves for the twin "V" belts, and guide flanges for securing the media. The two sections shall be welded together to form a tubular structure for improved strength in order to maintain an accurate radius and rotor roundness during the manufacturing process.

G. The rotor media shall be provided in segments to allow for field erection or replacement of one section of media at a time without side access. No external pullers or other special tooling shall be required for field assembly or replacement. The media shall be machined to fit in between a primary and secondary spoke and a guiding flange of the outside rim. Each media segment shall be compressed independently of all other segments during manufacturing without causing any angular deformation and resulting misfits between the spokes and media parts. The results shall be a wheel with a flatness of +/- 1/32 inch. No adhesive or silicone shall be necessary to secure the media in place.

H. The enthalpy heat transfer media shall be the industry standard of 200 mm. in depth. Non-standard depths shall be unacceptable. The heat transfer media shall be made out of corrugated aluminum foil with a high surface area per volume and laminar flow to assure that no fouling occurs on the internal heat transfer surface. Dry particles up to 900 microns shall pass freely through the media. This material shall be supplied with a "Balanced Sieve" (4A or 3A Molecular Sieve) hygroscopic solid desiccant coating for selective adsorption of water vapor and equal sensible and latent heat transfer. The media shall have a flame spread of 0 and a smoke developed of 5 or less when rated in accordance with ASTM E84-09. All edges shall have an anti-corrosion epoxy coating.

I. Rotor media shall be tested in accordance with ASHRAE Standard 84-91 and ARI Standard 1060-01 by a qualified independent testing laboratory. Testing shall confirm published performance and document that the desiccant material does not transfer pollutants typically encountered in the indoor air environment. The reports shall be provided upon request.

J. The seals shall be of a maintenance free “non-contact” type with a 4-pass labyrinth “turbine” for optimum performance and designed to eliminate wear and excessive drag. The seals shall be adjustable and set to within 0.05 inch of the rotor surface and must be bolted to the frame with stainless steel hardware to eliminate seal movement. The seal system shall withstand a pressure difference up to 12 in. W.C.

K. The drive system shall be a direct drive motor and speed reducer attached to the extended main shaft via a key way. Belt driven configuration will not be approved. This system eliminates the need for belts. The drive system shall be easily accessible and visible for inspection and maintenance and have a minimum life expectancy of 90,000 hours.

L. The speed control system shall be a variable frequency inverter operating a standard inverter rated AC motor, capable of operating the rotor from 1/4 rpm to 20 rpm or to whatever is required for the type of media used. It shall integrate with the temperature control system to provide the required supply air temperature.

M. The BACS shall monitor entering and leaving temperatures for the exhaust and supply air. Adjustable set points shall be for the heating mode discharge temperature, summer/winter change over and for wheel frost control. For multiple rotors in a common air stream each rotor shall provide temperature outputs to the controller in order to get an accurate average discharge temperature.

N. The rotation detector shall be accomplished through the temperature controller. A proximity sensor and target shall provide the contact for the controller used to provide RPM readout and wheel stoppage alarm contacts.

O. The entire rotor and wheel assembly shall require only limited maintenance of biannual greasing of the main bearings and inspection of the drive system.

P. A standard 10-year material and labor warranty shall be provided covering all materials supplied and installed.

Q. Temperature and speed sensors shall be provided by BACS contractor. To be factory installed by AHU manufacturer each with 100’ of wiring for BMS connection in the field.

1. Temperature sensor – Carel type NTC*WP* or approved equal.

2. Speed sensor – Reed based magnetic proximity sensor in aluminum threaded housing, Cherry type MP200701 or approved equal.

2.9 ELECTRICAL

A. Unit shall have a single point connection for main power.

B. Single non-fused disconnect switch shall be provided for connecting electrical power at the unit.

C. Disconnect switches shall be mounted internal to the control panel and operated by an externally mounted handle. Externally mounted handle is designed to prohibit opening of the control panel door without the use of a service tool.

D. An interlocking mechanism is furnished on the fan section access door. The de-energizing switch is compliance with CAL-OSHA, ETL and the mechanical protection requirements of UL 1995.

E. Motor starter panels with main disconnect.

F. Each motor is wired to a junction box mounted on the unit exterior.

G. Each motor is wired to a non-fused disconnect with auxiliary switch.

H. Units are equipped with vapor proof light fixture(s) with fluorescent bulbs (with guard). Unit drawing's fixture locations are approximate. Lights shall be controlled by one switch or each light will have its own switch. Refer to unit plans for details. Conduit for lights and outlets shall be electrical metallic tube (EMT). Flexible conduit connections shall be liquid tight. All junction boxes shall be gasketed.

I. 120 volt G.F.I convenience outlets provided. See drawings for quantity and locations

J. Motor Wiring

1. Motor shall be wired to NEMA-1 enclosure located on the exterior of unit fan housing. Conduit shall be appropriately sized EMT with a 3 ft. section of Greenfield flex conduit at the motor to provide a vibration loop. EMT conduit used up to 100 HP, TEK wire used on 100 HP and up, when single point wiring is required.

K. Starters, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 16.

L. ERV tag must bare the ETL label

2.10 SOUND POWER LEVELS

A. The maximum sound power level at the air handling unit discharge, return air inlet, fresh air inlet, and/or casing radiated shall not exceed the values given in the schedule below, when operating at the maximum design airflow and static pressure conditions

B. It shall be the option of the contractor to provide a quieter fan, acoustical lining, sound traps and/or other sound attenuating devices within the air handling unit to supplement the design in order to comply with the sound power levels specified above.

C. Air handling unit sound power level data shall be submitted to the mechanical and acoustical engineers for approval. The submitted data shall be based on sound power measurements on similar units. The submittal shall include a complete description of the methods and procedures used to develop the sound power levels being submitted

and the submitted sound power level will be verified for a limited number of units described below by measurement of the sound power.

2.11 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Water Coils: Factory tested to 300 psig (2070 kPa) according to ARI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products under the supervision of the owner's representative and per the manufacturer's Installation, Operation & Maintenance Instructions. Store in a clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures and finish.

3.2 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated, and the fan(s) has been test run under observation.

3.3 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 INSTALLATION

A. Equipment Mounting: Install air-handling unit using elastomeric pads . Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: 1/4 inch (6 mm).

2. Install galvanized -steel plate to equally distribute weight over elastomeric pad.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

C. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

D. Contractor shall coordinate shipping split dimensions to facilitate AHU/ERV installation within building. Include shipping slip configuration in shop drawings and AHU/ERV submittals. Field joining shall be accomplished using instructions and materials supplied by the unit manufacturer, and shall be capable of providing a factory quality seal.

E. Site Assembled / Knockdown construction (Kit Units):

1. Unit shall be shipped in pieces on pallets small enough to fit through the available opening(s), yet large enough to minimize work required in the field by installing contractor. Each piece or assembly of pieces shall be clearly marked and refer to a clear and concise assembly drawing. Factory authorized personnel shall be provided to supervise the assembly from start to finish (upon request and availability). Manufacturer shall guarantee the performance of the field assembled units just as if they were built in the factory. Approval by factory personnel shall confirm that installing contractor followed all assembly procedures and that unit will perform as specified

2. The unit manufacturer shall supply all necessary gasketing, sealant, installation instructions and supervision.

3. Provide factory fabricated and option for factory tested air handling units with components as indicated and scheduled on the drawings, to provide the services designated. Site assembled (knockdown) AHU’s/ERV’s must first be assembled in the factory to ensure fit and form prior to being shipped in labelled individual pallets for walls, base, roof, accessories, fans and other components.

4. Site assembled (knockdown) AHU’s, ERV’s do not require factory testing but fanwall cubes shall be balanced prior to shipping.

5. Site assembled (knockdown) AHU's, ERV's shall be provided with an on site casing leakage test.

F. Align, level, bolt in place and grout.

G. Install in conformance with ARI 435.

H. Assemble and install in strict accordance with manufacturer's Operation & Maintenance Instructions, shop drawings and contract documents.

3.5 CONNECTIONS

A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4 DN 50 minimum or connection size, ASTM B 88, Type MASTM B 88M, Type C copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

Connect duct to air-handling units with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories."

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. The air handling unit manufacturer shall perform a leakage test on the air handling unit once assembled on site after all penetrations are in

place and sealed. This test shall be witnessed by representatives from Cornell University and the Project Engineer of Record.

2. Charge refrigerant coils with refrigerant and test for leaks.

3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

5. Manufacturers field service agent to perform a leakage test once the unit is assembled on site with all penetrations in place and sealed. Test to be witnessed by Cornell University and Project engineer of record. Provide 2 weeks notice.

D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Verify that shipping, blocking, and bracing are removed.

3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.

4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.

5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.

6. Verify that zone dampers fully open and close for each zone.

7. Verify that face-and-bypass dampers provide full face flow.

8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.

9. Comb coil fins for parallel orientation.

10. Verify that proper thermal-overload protection is installed for electric coils.

11. Install new, clean filters.

12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.

2. Measure and record motor electrical values for voltage and amperage.

3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.8 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.9 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

End of Section

Section 23 82 16.11

HYDRONIC AIR COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes hydronic heating and cooling air coils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

B. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for ASHRAE 62.1.>

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 COILS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aerofin.
2. Carrier Corporation.
3. Coil Company, LLC.
4. Greenheck Fan Corporation.
5. Modine Commercial and Industrial Solutions.
6. RAE Coils; a division of RAE Corporation.
7. Super Radiator Coils.
8. Trane.
9. USA Coil & Air.

B. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

D. Source Quality Control: Factory tested to 300 psig (2070 kPa).

E. Type "WC" Chilled or Hot Water Coils
1. Primary Tube Surface
   a. Round seamless 5/8" O.D. copper tubes with 0.035" wall thickness mechanically expanded into fin collars of the secondary surface. Tubes shall be mechanically expanded to provide a permanent metal-to-metal bond for efficient heat transfer. Manufacturer may only use staggered tubes in direction of airflow and only return bends - reduced tube wall hairpin bends are not acceptable. 10 rows maximum.
2. Secondary Fin Surface
   a. Die-formed, corrugated plate-type 0.008" Aluminum fins with full drawing fin collars to provide accurate fin spacing control and maximum tube contact. 12 fins per inch maximum.
3. Headers
   a. Seamless copper with die-formed holes to provide a parallel surface to the coil tube for strong brazing joints. Coil is supplied with 1/8" brass female pipe thread (FPT) vents and drains. All circuiting is designed to gravity-drain.
4. Connections
   a. Red Brass Schedule 40 male pipe thread (MPT) to prevent dielectric reaction between dissimilar metals.
5. Casing

a. Minimum 16 ga. 304 Stainless Steel with 1-1/2" die-formed flanges to permit easy stacking and mounting. Intermediate tube supports are supplied on coils over 44" fin length with additional supports every 42" multiple thereafter.

6. Testing and Performance
   a. All coil assemblies are leak tested under water at 500 PSIG. Standard construction is suitable for 250 PSIG operating pressure up to 300° F. PERFORMANCE is CERTIFIED under ARI Standard 410. All coil performance ratings are generated with manufacturer's ARI certified selection software.
7. Provide removable panels on both sides of the all coils.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Install stainless steel drain pan under each cooling coil.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
3. Extend drain pan upstream and downstream from coil face.
4. Extend drain pan under coil headers and exposed supply piping.

D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

E. Straighten bent fins on air coils.

F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232116 "Hydronic Piping Specialties."

End of Section

Section 23 82 19

FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes fan-coil units and accessories.

1.3 DEFINITIONS

A. BMS: Building Management system.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification: For each type of fan-coil unit indicated.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension components.
2. Structural members to which fan-coil units will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

B. Field quality-control test reports.

C. Warranty: Special warranty specified in this Section.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan-Coil-Unit Filters: Furnish 1 set of spare filters for each filter installed.
2. Fan Belts: Furnish 1 set of spare fan belts for each unit installed.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.9 COORDINATION

A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake.

PART 2 - PRODUCTS

2.1 DUCTED FAN-COIL UNITS

A. Basis-of-Design Product: Subject to compliance with requirements, all vertical four-pipe fan coil units shall be manufactured by Johnson Controls as the basis of design. All cooling only fain col units shall be manufactured by Titus, as the basis-of-design. Other manufacturers offering similar products may be incorporated, they include and are limited to, the following:

1. Airtherm
2. Enviro-Tec
3. International Environmental Corporation.
4. Trane
5. Or Approved Equal.

B. GENERAL

1. Furnish and install Horizontal Direct Drive Fan Coil Units where indicated on the plans and in the specifications. Units shall be completely factory assembled, tested and shipped as one piece. Units shall be capable of meeting or exceeding the scheduled capacities for cooling, heating and air delivery. Unit dimensions for each model and size shall be considered maximums.

2. Units shall be cETLus listed in compliance with UL/ANSI Standard 1995, and be certified as complying with the latest edition of AHRI Standard 440.

C. CONSTRUCTION

1. Unit chassis shall be fabricated of galvanized steel panels. Exterior panels shall be insulated with 3/8" thick elastomeric closed cell foam Insulation. Insulation shall conform to UL 181 for erosion and NFPA 90A for fire and smoke, and comply with a 25/50 Flame Spread and Smoke Developed Index per ASTM E-84 or UL 723. Additionally, insulation shall comply with Antimicrobial Performance

Rating of 0, no observed growth, per ASTM G-21. Polyethylene insulation is not acceptable. Ducted units shall have a minimum 1-1/2" duct collar on the discharge. Plenum and exposed units shall have a minimum 3/4" duct collar on the return. Exposed units shall have exterior panels fabricated of galv steel. The fan and filter bottom access panel shall be attached with quarter turn quick open fasteners to allow for easy removal and access for service. Unit mounting shall be by hanger brackets provided at four locations.

2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. PAINTED FINISH

1. Painted cabinet exterior panels shall be finished with a heat cured anodic acrylic powder paint of the standard factory color.

E. SOUND

1. Ducted units shall have published sound power level data tested in accordance with AHRI Standard 260-2012. Exposed units shall have published sound power level data tested in accordance with AHRI Standard 350-2015 (non-ducted equipment).

F. FAN ASSEMBLY

1. Unit fan shall be a dynamically balanced, forwardly curved, DWDI centrifugal type constructed of 18 gauge zinc coated galvanized steel for corrosion resistance. Motors shall be Electronically Commutated (EC), permanently lubricated sleeve bearing, and CSA listed automatic reset thermal overload protection and three separate horsepower taps. Single speed motors are not acceptable. The fan assembly shall be easily removable for servicing the motor and blower at, or away from the unit. The entire fan assembly shall be able to come out of the unit by removing two screws and unplugging the motor. Plenum unit fan assemblies shall be easily serviced through an access panel in casing. Devices used to energize and de-energize (switch) fan speeds must be silent. Magnetic, mercury, and/or quiet relays and/or contactors are not acceptable.

2. Electronically Commutated (EC) Motor. Motor shall be capable of accepting a 2-10 VDC output from BAS.

3. Standard High-efficiency Variable speed ECM motor available for higher energy

4. Motor: ECM variable speed DC brushless motors specifically designed for use with a single phase, 60Hz, electrical input. Motor shall be complete with and operated by a single phase integrated controller/inverter that operates the wound stator and senses rotor position to electrically commutate the stator. Motor shall have built in soft start and slow speed change ramps. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment".

5. The speed controller shall have a turn down stop to prevent the possibility of harming the motor bearings, and incorporate electrical noise suppression to minimize noise on the incoming power lines.

6. Devices used to energize and de-energize (switch) fan speeds must be totally silent. Magnetic, mercury, and/or quiet relays and/or contactors are not acceptable.

G. COILS - Type "WC" Chilled and Hot Water Coils

1. Primary Tube Surface
   a. Round seamless 1/2" O.D. copper tubes with 0.016" wall thickness mechanically expanded into fin collars of the secondary surface. Tubes shall be mechanically expanded to provide a permanent metal-to-metal bond for efficient heat transfer. Manufacturer may only use staggered tubes in direction of airflow and only return bends - reduced tube wall hairpin bends are not acceptable. 10 rows maximum.

2. Secondary Fin Surface
   a. Die-formed, corrugated plate-type 0.008" Aluminum fins with full drawing fin collars to provide accurate fin spacing control and maximum tube contact. 12 fins per inch maximum.

3. Headers
   a. Seamless copper with die-formed holes to provide a parallel surface to the coil tube for strong brazing joints. Coil is supplied with 1/8" brass female pipe thread (FPT) vents and drains. All circuiting is designed to gravity-drain.

4. Connections
   a. Red Brass Schedule 40 male pipe thread (MPT) to prevent dielectric reaction between dissimilar metals.

5. Casing
   a. Minimum 16 ga. 304 Stainless Steel with 1-1/2" die-formed flanges to permit easy stacking and mounting. Intermediate tube supports are supplied on coils over 44" fin length with additional supports every 42" multiple thereafter.

6. Testing and Performance
   a. All coil assemblies are leak tested under water at 500 PSIG. Standard construction is suitable for 250 PSIG operating pressure up to 300° F. PERFORMANCE is CERTIFIED under ARI Standard 410. All coil performance ratings are generated with manufacturer's ARI certified selection software.

7. Applied fixtures/lamps must be specifically manufactured for this purpose. Safety interlocks/features shall be provided to limit hazard to operating staff.

8. Provide removable panels on both sides of the all coils.

H. DRAIN PANS

1. Primary condensate drain pans shall be single wall, constructed entirely of heavy gauge stainless steel for superior corrosion resistance. Stainless steel drain pans shall be externally insulated and extend under the entire cooling coil.

2. Drain pans shall be of one-piece construction and be double sloped for condensate removal. Drain pans shall be fully removable without the use of any tools.

3. The drain pan shall be externally insulated with a fire retardant, closed cell foam insulation. The insulation shall carry no more than a 25/50 Flame Spread and Smoke Developed Rating per ASTM E-84 and UL 723 and an Antimicrobial Performance Rating of 0, no observed growth, per ASTM G-21.

4. Fabricate pans and drain connections to comply with ASHRAE 62.1.

5. Drain pans shall be able to accommodate installation and interface with over flow detection at drain pan, conforming to UL508, in that will shut off the unit CHW control valve in the event of a primary drain blockage and raise an alarm at the BMS. Refer to controls section for device specifications.

I. FILTERS

1. All plenum and exposed units shall be furnished with a minimum 1" nominal glass fiber throwaway filter. Filters shall be tight fitting to prevent air bypass. Plenum unit filters shall be easily removable from the bottom of the unit without the need for tools.

2. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

J. ELECTRICAL

1. Units shall be furnished with single point power connection. Provide an electrical junction box with terminal strip for motor and other electrical terminations.

K. SOUND

1. Units shall have published sound power level data tested in accordance with AHRI Standard 350-2000 (nonducted equipment) and AHRI Standard 260-2001 (ducted equipment).

L. BMS Interface Requirements:

1. All controls to be provided by the control’s contractor. Refer to the controls sequences and diagrams.

2. Electrical Connection: wire motors and controls for a single electrical connection.

2.2 BLOWER-COIL UNITS (BCU)

A. Basis-of-Design Product: Subject to compliance with requirements, all blower coil units shall be manufactured by Titus, as the basis-of-design. Other manufacturers offering similar products may be incorporated, they include and are limited to, the following:

1. Airtherm
2. Enviro-Tec
3. International Environmental Corporation.
4. Trane
5. Or Approved Equal.

B. GENERAL

1. Furnish and install TITUS Horizontal Direct Drive Fan Coil Units where indicated on the plans and in the specifications. Units shall be completely factory assembled, tested and shipped as one piece. Units shall be capable of meeting or exceeding the scheduled capacities for cooling, heating and air delivery. Unit dimensions for each model and size shall be considered maximums.

2. Units shall be cETLus listed in compliance with UL/ANSI Standard 1995, and be certified as complying with the latest edition of AHRI Standard 440.

C. CONSTRUCTION

1. Unit chassis shall be fabricated of galvanized steel panels. Exterior panels shall be insulated with 3/8" thick elastomeric closed cell foam Insulation. Insulation shall conform to UL 181 for erosion and NFPA 90A for fire and smoke, and comply with a 25/50 Flame Spread and Smoke Developed Index per ASTM E-84 or UL 723. Additionally, insulation shall comply with Antimicrobial Performance Rating of 0, no observed growth, per ASTM G-21. Polyethylene insulation is not acceptable. Ducted units shall have a minimum 1-1/2" duct collar on the discharge. Plenum and exposed units shall have a minimum 3/4" duct collar on the return. Exposed units shall have exterior panels fabricated of galv steel. The fan and filter bottom access panel shall be attached with quarter turn quick open fasteners to allow for easy removal and access for service. Unit mounting shall be by hanger brackets provided at four locations.

2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. PAINTED FINISH

1. Painted cabinet exterior panels shall be finished with a heat cured anodic acrylic powder paint of the standard factory color.

E. SOUND

1. Ducted units shall have published sound power level data tested in accordance with AHRI Standard 260-2012. Exposed units shall have published sound power level data tested in accordance with AHRI Standard 350-2015 (non-ducted equipment).

F. FAN ASSEMBLY

1. Unit fan shall be a dynamically balanced, forwardly curved, DWDI centrifugal type constructed of 18 gauge zinc coated galvanized steel for corrosion resistance. Motors shall be Electronically Commutated (EC), permanently

lubricated sleeve bearing, and CSA listed automatic reset thermal overload protection and three separate horsepower taps. Single speed motors are not acceptable. The fan assembly shall be easily removable for servicing the motor and blower at, or away from the unit. The entire fan assembly shall be able to come out of the unit by removing two screws and unplugging the motor. Plenum unit fan assemblies shall be easily serviced through an access panel in casing. Devices used to energize and de-energize (switch) fan speeds must be silent. Magnetic, mercury, and/or quiet relays and/or contactors are not acceptable.

2. Electronically Commutated (EC) Motor. Motor shall be capable of accepting a 2-10 VDC output from BAS.

3. Standard High-efficiency Variable speed ECM motor available for higher energy

4. Motor: ECM variable speed DC brushless motors specifically designed for use with a single phase, 60Hz, electrical input. Motor shall be complete with and operated by a single phase integrated controller/inverter that operates the wound stator and senses rotor position to electrically commutate the stator. Motor shall have built in soft start and slow speed change ramps. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment".

5. The speed controller shall have a turn down stop to prevent the possibility of harming the motor bearings, and incorporate electrical noise suppression to minimize noise on the incoming power lines.

6. Devices used to energize and de-energize (switch) fan speeds must be totally silent. Magnetic, mercury, and/or quiet relays and/or contactors are not acceptable.

G. COILS - Type "WC" Chilled or Hot Water Coils

1. Primary Tube Surface
   a. Round seamless 5/8" O.D. copper tubes with 0.035" wall thickness mechanically expanded into fin collars of the secondary surface. Tubes shall be mechanically expanded to provide a permanent metal-to-metal bond for efficient heat transfer. Manufacturer may only use staggered tubes in direction of airflow and only return bends - reduced tube wall hairpin bends are not acceptable. 10 rows maximum.

2. Secondary Fin Surface
   a. Die-formed, corrugated plate-type 0.008" Aluminum fins with full drawing fin collars to provide accurate fin spacing control and maximum tube contact. 12 fins per inch maximum.

3. Headers
   a. Seamless copper with die-formed holes to provide a parallel surface to the coil tube for strong brazing joints. Coil is supplied with 1/8" brass female pipe thread (FPT) vents and drains. All circuiting is designed to gravity-drain.

4. Connections
   a. Red Brass Schedule 40 male pipe thread (MPT) to prevent dielectric reaction between dissimilar metals.

5. Casing
   a. Minimum 16 ga. 304 Stainless Steel with 1-1/2" die-formed flanges to permit easy stacking and mounting. Intermediate tube supports are supplied on coils over 44" fin length with additional supports every 42" multiple thereafter.

6. Testing and Performance
   a. All coil assemblies are leak tested under water at 500 PSIG. Standard construction is suitable for 250 PSIG operating pressure up to 300° F. PERFORMANCE is CERTIFIED under ARI Standard 410. All coil performance ratings are generated with manufacturer's ARI certified selection software.

7. Applied fixtures/lamps must be specifically manufactured for this purpose. Safety interlocks/features shall be provided to limit hazard to operating staff.

8. Provide removable panels on both sides of the all coils.

H. DRAIN PANS

1. Primary condensate drain pans shall be single wall, constructed entirely of heavy gauge stainless steel for superior corrosion resistance. Stainless steel drain pans shall be externally insulated and extend under the entire cooling coil.

2. Drain pans shall be of one-piece construction and be double sloped for condensate removal. Drain pans shall be fully removable without the use of any tools.

3. The drain pan shall be externally insulated with a fire retardant, closed cell foam insulation. The insulation shall carry no more than a 25/50 Flame Spread and Smoke Developed Rating per ASTM E-84 and UL 723 and an Antimicrobial Performance Rating of 0, no observed growth, per ASTM G-21.

4. Fabricate pans and drain connections to comply with ASHRAE 62.1.

5. Drain pans shall be able to accommodate installation and interface with over flow detection at drain pan, conforming to UL508, in that will shut off the unit CHW control valve in the event of a primary drain blockage and raise an alarm at the BMS. Refer to controls section for device specifications.

I. FILTERS

1. All plenum and exposed units shall be furnished with a minimum 1" nominal glass fiber throwaway filter. Filters shall be tight fitting to prevent air bypass. Plenum unit filters shall be easily removable from the bottom of the unit without the need for tools.

2. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

J. ELECTRICAL

1. Units shall be furnished with single point power connection. Provide an electrical junction box with terminal strip for motor and other electrical terminations.

K. SOUND

1. Units shall have published sound power level data tested in accordance with AHRI Standard 350-2000 (nonducted equipment) and AHRI Standard 260-2001 (ducted equipment).

L. BMS Interface Requirements:

1. Control devices and operational sequences are specified in Section 230900 "Building Control System" and Section 230993 "Sequence and Operations for HVAC Controls."

2. Interface relay for scheduled operation.

3. Interface relay to provide indication of fault at the central BMS workstation.

4. Provide BACnet interface for central BMS workstation for the following functions:

   a. Adjust set points.
   b. Fan-coil-unit start, stop, and operating status.
   c. Data inquiry, including outdoor-air damper position, supply- and room-air temperature.
   d. Occupied, Occupied Standby and unoccupied schedules.

5. Electrical Connection: wire motors and controls for a single electrical connection.

2.3 DUCTLESS FAN COIL UNITS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Titus or comparable product by one of the following:

1. Daikin Applied.
2. ENVIRO-TEC; by Johnson Controls, Inc.
3. Nailor Industries Inc.
4. Trane Inc.
5. YORK; a Johnson Controls company.

B. Fan Coil Unit Configurations: Row split.

1. Number of Cooling Coils: One with two-pipe system.

C. Coil Section Insulation: 1-inch-thick, coated glass fiber complying with ASTM C1071 and attached with adhesive complying with ASTM C916.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.

2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Coil Section Insulation: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.

2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Main and Auxiliary Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable.

F. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.

G. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color as selected by Architect.

1. Vertical Unit Front Panels: Removable, steel, with integral stamped steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.

2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped discharge grilles.

3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from manufacturer's standard colors. Return grille shall provide maintenance access to fan coil unit.

4. Steel recessing flanges for recessing fan coil units into ceiling or wall.

H. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.

1. MERV Rating: 8 when tested according to ASHRAE 52.2.

I. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

J. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.

2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

3. Wiring Termination: Connect motor to chassis wiring with plug connection.

K. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

Retain last paragraph above and delete "Basic Unit Controls" Paragraph below if controls are part of overall temperature-control system.

Retain "(DDC)Terminal Controller" Paragraph below and coordinate with "Basic Unit Controls" Paragraph above or with control devices specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

L. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan-coil units level and plumb.

B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Architects, drawings and room details before installation. Install devices 48 inches above finished floor.

E. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.

2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.

3. Connect condensate drain to indirect waste.

a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

4. Provide automatic condensate drain pumps where space conditions do not allow for gravity draining of coil condensate.

B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied

conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan-coil units. Refer to Section 017900 "Demonstration and Training."

End of Section

Section 23 82 39

UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Propeller unit heaters with hot-water coils.
   2. Cabinet Unit Heaters with hot water coils.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CWP: Cold working pressure.

C. PTFE: Polytetrafluoroethylene plastic.

D. TFE: Tetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

   1. Plans, elevations, sections, and details.
   2. Location and size of each field connection.
   3. Details of anchorages and attachments to structure and to supported equipment.
   4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
   5. Location and arrangement of piping valves and specialties.
   6. Location and arrangement of integral controls.
   7. Wiring Diagrams: Power, signal, and control wiring.

C. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

D. Samples for Verification: Finish colors for each type of cabinet unit heater and wall and ceiling heaters indicated with factory-applied color finishes.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.8 SUSTAINABLE DESIGN INTENT

A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

PART 2 - PRODUCTS

2.1 PROPELLER UNIT HEATERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Sterling
2. Trane
3. Reznor
4. QMark Electric Heating; a division of Marley Engineered Products.
5. Or Approved Equal.

B. Description: An assembly including casing, coil, fan, and motor in vertical and horizontal discharge configuration with adjustable discharge louvers.

C. Comply with UL 2021.

D. Comply with UL 823.

E. Cabinet: Removable panels for maintenance access to controls.

F. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.

G. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

H. General Coil Requirements: Test and rate hot-water propeller unit heater coils according to ASHRAE 33.

I. Hot-Water Coil: Copper tube, minimum 0.025 in wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1in and rated for a minimum working pressure of 300 PSI and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 PSI underwater.

J. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

K. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Type: Permanently lubricated, variable speed.

L. Control Devices:

1. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls."

2. BMS contractor to provide unit heater controls, including:

1) Control valve
2) Thermostat
3) Aquastat

2.2 CABINET UNIT HEATERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product listed on the plans or a comparable product by one of the following:
1. Airtherm; a Mestek Company.
2. Berko Electric Heating; a division of Marley Engineered Products.
3. Chromalox, Inc.; a division of Emerson Electric Company.
4. Dunham-Bush, Inc.
5. Indeeco.
6. Markel Products; a division of TPI Corporation.
7. QMark Electric Heating; a division of Marley Engineered Products.
8. Rittling.
9. Or Approved Equal.

B. Description: A factory-assembled and -tested unit complying with ARI 440.

C. Coil Section Insulation: ASTM C 1071; surfaces exposed to airstream shall be erosion-resistant coating to prevent erosion of glass fibers.
1. Thickness: 1 inch.
2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Coil Section Insulation: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.
1. Thickness: 1/2 inch.
2. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

E. Cabinet: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
1. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch- thick, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
2. Recessing Flanges: Steel, finished to match cabinet.
3. Control Access Door: Key operated.
4. False Back: Minimum 0.0428-inch- thick steel, finished to match cabinet.

5. Washable Foam: 70 percent arrestance and 3 MERV.

F. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 300 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

G. Fan and Motor Board: Removable.
1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

H. Factory, Hot-Water Piping Package: ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet and outlet.

1. Hose Kits: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.
   a. Length: 36 inches.
   b. Minimum Diameter: Equal to cabinet unit heater connection size.
2. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
3. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A 126, Class B); 300-psig minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 threaded pipe and full-port ball valve in strainer drain connection.
4. Wrought-Copper Unions: ASME B16.22.

I. Control devices and operational sequences are specified in Section 230900 "Building Control System" and Section 230993 "Sequence and Operations for HVAC Controls."

1. BMS contractor to provide unit heater controls, including:
   a. Control valve
   b. Thermostat
   c. Aquastat

J. Electrical Connection: Factory wire motors and controls for a single field connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants."

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Install propeller unit heaters level and plumb.

D. Suspend cabinet unit heaters from structure with Spring hangers. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

E. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers. Hanger rods and attachments to structure are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

F. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

G. Install piping adjacent to unit to allow service and maintenance.

H. Install units to allow service and maintenance, including all clearance requirements.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."

E. Comply with safety requirements in UL 1995.

F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Division 23 Section "Hydronic Piping."

G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

B. Refer to Division 01 Section "Demonstration and Training."

End of Section

Section 23 83 16

RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes radiant-heating piping, including:
1. PEX pipe and fittings.
2. PEX-AL-PE pipe and fittings.
3. PEX-AL-PEX pipe and fittings.
4. Piping specialties.
5. Distribution manifolds and compatible fittings.
6. Fasteners approved by manufacturer.
7. Mixing assemblies.
8. Controls.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. PEX: Crosslinked polyethylene.

C. PEX/AL/PEX: Crosslinked polyethylene/aluminum/crosslinked polyethylene.

D. PTFE: Polytetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fire-performance characteristics, and water-flow and pressure-drop characteristics.

B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.

1. Shop Drawing Scale: 1/4 inch = 1 foot.

C. Calculation Reports: Show output of the heating/cooling system to include any excess or shortages of heating or cooling, heating/cooling entering the space, flow rates, head loss, back losses of heating/cooling, floor covering resistance, and floor surface temperatures.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For radiant-heating piping valves and equipment to include in operation and maintenance manuals.

1.6 WARRANTY

A. Manufacturer warranty shall include the following:
   1. In the event that manufacturer determines that the failure or leak and any resulting damages were the result of a manufacturing defect in the products covered by the warranty and occurred during the first ten years of the time period covered by the warranty, the manufacturer will reimburse the property owner for reasonable repair or replacement charges resulting from the failure or leak and, additionally will reimburse damages to personal property resulting from the failure or leak.
   2. Radiant heat pipe manufacturer shall warranty the tubing under normal conditions of use and properly maintained, will be free from failure caused by manufacturing defect for a period of thirty (30) years from date of installation, when properly installed by contractors trained by manufacturer.
   3. PEX Press fittings, when installed with ViegaPEX Barrier and FostaPEX tubing, will be free from failure caused by manufacturing defect for a period of thirty (30) years from date of installation. This also includes protected PEX Press fitting in a slab.
   4. Manifolds and panels used in the system will be free from manufacturing defect for a period of five (5) years.
   5. Controls, mixing stations, or electrical components sold by manufacturer shall be free from manufacturing defect for a period of two (2) years from date of installation.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Viega LLC; or a comparable product by one of the following:
   1. Heat Innovations Inc.
   2. Infloor Radiant Heating Inc.
   3. IPEX USA LLC.
   4. Slant/Fin Corporation.
   5. Uponor.
   6. Zurn Industries, LLC.

B. Pipe Material: PEX plastic according to ASTM F876.
   1. 9001 or NSF International in the manufacturing plant to assure that the tubing and fittings are continually being produced to the required standard.
   2. Tubing shall be silane cross-linked high density polyethylene as per ASTM F876/F877 and CSA B137.5.
   3. Tubing includes four layers.
      a. First layer: Cross-linked, high density polyethylene.
      b. Second layer: Adhesive.
      c. Third layer: Ethylene vinyl alcohol layer (EVOH oxygen barrier).
      d. Fourth layer: Polyethylene to protect the EVOH layer from damage.
   4. Certified to NSF 14 and 61.
   5. Tubing will have 6 month UV protection.

C. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.

D. Bronze Fittings: PEX Press Fittings manufactured from UNS C87700 copper alloy, meeting the requirements of ASTM F 877 tested as a system with ViegaPEX Barrier tubing.
   1. PEX Press Sleeve: Manufactured out of a 304 grade or better stainless steel, and have three view holes with an attached sleeve to ensure proper PEX tubing insertion.
   2. Attached sleeve fitting will incorporate a tool locator ring that shall be in place while making a proper press connection.
   3. PEX Press connection shall be made with a Viega supplied ratcheting PEX Press hand tool or PEX Press power tool.

E. Polymer Fittings: PEX Press Fittings manufactured from Radel-R® polymer, meeting the requirements of ASTM F 877 tested as a system with Viega PEX Barrier tubing.
   1. PEX Press Sleeve: Manufactured out of a 304 grade or better stainless steel and have three view holes with an attached sleeve to ensure proper PEX tubing insertion.
   2. Fitting will include the Smart Connect feature providing quick easy identification of unpressed connections during the pressure testing process.
   3. Unpressed connections are located by pressurizing the system to 0.5 psi to 100 psi.
   4. Attached sleeve fitting will incorporate a tool locator ring that shall be in place while making a proper press connection.
   5. PEX Press connection shall be made with a Viega supplied ratcheting PEX Press hand tool or PEX Press power tool.

F. Pressure/Temperature Rating: ViegaPEX Barrier High-Density Cross-linked polyethylene tubing shall meet the standard grade hydrostatic pressure ratings from the Plastic Pipe Institute in accordance with TR-4/03. The following three ratings are required:
   1. 200 deg F at 80 psi.
   2. 180 deg F at 100 psi
   3. 73.4 deg F at 160 psi

2.2 PEX/AL/PE PIPE AND FITTINGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Viega LLC

B. Pipe Material:
1. Viega FostaPEX tubing and fittings shall maintain a quality control program in accordance with ISO 9001 or NSF International, and IAPMO R&T in the manufacturing plant to assure that the tubing and fittings are continually being produced to the required standard.
2. Tubing shall be silane cross-linked high density polyethylene as per ASTM F 876/F 877 and CSA B137.5.
3. Tubing is produced to IAPMO Standard IGC 212.
4. Tubing includes three (3) layers:
   a. First layer is cross-linked, high density polyethylene.
   b. Second layer is aluminum.
   c. Third layer is polyethylene.
5. Certified to NSF 14 and 61.
6. Tubing will have 6 month UV protection or longer.

C. Bronze Fittings: PEX Press Fittings manufactured from UNS C87700 copper alloy, meeting the requirements of ASTM F 877 tested as a system with ViegaPEX tubing.
1. PEX Press Sleeve: Manufactured out of a 304 grade or better stainless steel, and have three view holes with an attached sleeve to ensure proper PEX tubing insertion.
2. Attached sleeve fitting will incorporate a tool locator ring that shall be in place while making a proper press connection.
3. PEX Press connection shall be made with a Viega supplied ratcheting PEX Press hand tool or PEX Press power tool.

D. Polymer Fittings: PEX Press Fittings manufactured from Radel®R polymer, meeting the requirements of ASTM F 877 tested as a system with ViegaPEX tubing.
1. PEX Press Sleeve: Manufactured out of a 304 grade or better stainless steel, and have three view holes with an attached sleeve to ensure proper PEX tubing insertion.
2. Fitting will include the Smart Connect feature providing quick easy identification of unpressed connections during the pressure testing process.
3. Unpressed connections are located by pressurizing the system to 0.5 psi to 100 psi
4. Attached sleeve fitting will incorporate a tool locator ring that shall be in place while making a proper press connection.
5. PEX Press connection shall be made with a Viega supplied ratcheting PEX Press hand tool or PEX Press power tool.

E. Pressure/Temperature Rating: ViegaPEX Barrier High-Density Cross-linked polyethylene tubing shall meet the standard grade hydrostatic pressure ratings from the Plastic Pipe Institute in accordance with TR-4/03. The following three ratings are required:
1. 200 deg F at 80 psi.
2. 180 deg F at 100 psi .
3. 73.4 deg F at 160 psi

2.3 PEX-AL-PEX PIPE AND FITTINGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Viega LLC; or a comparable product by one of the following:
   1. Heat Innovations Inc.
   2. IPEX USA LLC.

B. Pipe Material: PEX plastic bonded to the inside and outside of a welded aluminum tube according to ASTM F 1281.

C. Oxygen Barrier: Limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.

D. Fittings: ASTM F 1974, metal insert fittings with split ring and compression nut (compression joint) or metal insert fittings with copper crimp rings (crimp joint).

E. Flame-Spread and Smoke-Developed Indices: 25 and 50 or less, respectively, tested according to ASTM E 84.

F. Pressure/Temperature Rating: Minimum 100 psig and 210 deg F.

2.4 DISTRIBUTION MANIFOLDS

A. Stainless Manifold with Balancing Valves and Flow Meters: Minimum NPS 1.
   1. Manifolds shall be made of 304 stainless steel with nickel-plate valve necks on select models.
   2. Flow meters, balancing valves, and shut off valves are integrated on manifold.
   3. Air bleeders and two purge valves are to be integrated on manifold.
   4. Manifolds have 1 inch NPT removable end caps and 1 1/4 inch Union connections.
   5. Galvanized steel bracket supplied by Viega.
   6. Select manifold cabinet based on manifolds, accessories and fittings added.
   7. Accept optional powerheads for individual zone control.
   8. Manifold is suitable to receive all SVC connections.
   9. Flow Meters for Stainless Manifolds:
      a. Visual Flow Indicator: Visible indication in a clear plastic cap at top of valve.
      b. Body Brass: Nickel plated.
      c. Internal Parts: Plastic, EPDM.
      d. Inlet Connection: NPS 1/2 , 1/2 inch with O-ring.
      e. Measure range: 0 - 2 gpm.
      f. Handle Style: Rotating ring with lockable cap, no memory stop to retain set position if used for shut off.
      g. CWP Rating: 100 psi.
   10. Thermometers:
      a. Mount on connection.
      b. Case: Stainless steel, 2 inch diameter.
      c. Element: Bimetal coil element.
      d. Movement: Mechanical, connecting element and pointer.
      e. Dial: White aluminum, black lettering.

f. Pointer: Aluminum, black.
g. Window: Instrument glass, NS 33 polycarbonate.
h. Connector: Rigid, back type.
i. Accuracy: Plus or minus 2 percent of range.

11. Maximum Operating Pressure: 100 psi .
12. Maximum Operating Temperature: 180 deg.

B. Stainless Manifolds with Balancing Valves: Minimum NPS 1 1/4.
1. Manifolds shall be made of 304 stainless steel with nickel-plate valve necks on select models.
2. Balancing valves and shut off valves are integrated on manifold.
3. Air bleeders and purge valves are to be integrated on manifold.
4. Manifolds have 1inch NPT removable end caps and 1 1/4 inch NPT Union connections.
5. Use bracket supplied by Viega.
6. Select manifold cabinet based on manifolds, accessories and fittings added.
7. Accept optional powerheads for individual zone control.
8. Manifold circuit connections are suitable to receive all SVC connections.
9. Maximum Operating Pressure: 100 psi .
10. Maximum Operating Temperature: 180 deg F.

C. Balancing Valves for Stainless Manifolds:
1. Body: Brass, nickel plated.
2. Valve Spindle: Brass, EPDM.
3. Inlet Connection: NPS 1/2, 1/2 inch with O-ring.
4. Operator: Allen Wrench - 5 mm.
5. CWP Rating: 145 psi.
6. Maximum Operating Pressure: 100 psi.
7. Maximum Operating Temperature: 180 deg F.

D. Stainless Manifold Valveless: NPS 1-1/4.
1. Manifolds shall be made of 304 stainless steel with nickel valve necks of select models.
2. Air bleeders are to be integrated on manifold.
3. Manifolds have 1 in NPT removable end caps and 1-1/4 in NPT Union connections.
4. Use bracket supplied by Viega.
5. Select manifold cabinet based on manifold accessories and fittings added.
6. Manifold circuit connections are suitable to receive all SVC connections.
7. Maximum Operating Pressure: 100 psi
8. Maximum Operating Temperature: 180 deg F.

E. Manual Air Vents:
1. Body: Brass, nickel-plated.
2. Operator: Key furnished with valve, or screwdriver bit.
3. Inlet Connection: NPS 1/2
4. Maximum Operating Pressure: 100 psi.
5. Maximum Operating Temperature: 180 deg F.

F. Main Shutoff Valves for Stainless Manifolds:
1. Field installed on supply and return connections.
2. Two-piece body.
3. Body: Brass nickel-plated body.

4. Ball: Full port chrome-plated brass.
5. Seals: PTFE.
6. Stem: Brass with 2 Buna-N O-rings and blowout proof assembly.
7. CWP Rating: 100 psig .
8. Maximum Operating Temperature: 180 deg F.

G. Powerheads for Stainless Manifolds (4-wire):
1. Integrated micro switch with floating contact.
2. Voltage: 24 VAC.
3. Maximum Inrush Current: Less than 300 mA for 2 minutes maximum.
4. Operating Power: 1 watt.
5. Closing/Opening Time: Approximately 3.5 minutes.
6. Stroke: 0.16 inch .
7. Actuating Force: 21 lbs.
8. Weight: 5.5 oz.
9. Fluid Temperature: 32 to 212 deg F.
10. End Switch: Normally open.
11. Micro Switch: 24 VAC / 0.5 A.
12. Switching Point: 0.08 inch .
13. Visual Function Indicator.
14. 360 degree Installation Position.
15. Snap-on Installation.

H. Powerheads for Stainless Manifolds (2-wire):
1. Voltage: 24 VAC.
2. Maximum Inrush Current: <300 mA for 2 minutes maximum.
3. Operating Power: 1 watt.
4. Closing/Opening Time: Approximately 3.5 minutes.
5. Stroke: 0.16 inch.
6. Actuating Force: 21 lbs
7. Weight: 5.5 oz
8. Fluid Temperature: 32 to 212 deg F.
9. Visual Function Indicator.
10. 360 degree Installation Position.
11. Snap-on Installation.

I. Copper Manifolds - Valved:
1. Manufactured to the requirements of ASTM B 88 and of type L copper.
2. Headers are fitted with shutoff or shutoff balancing valves with PEX Press connection type.

J. Copper Manifolds - Valveless:
1. Manufactured to the requirements of ASTM B 88 and of type L copper.

K. Pressure Seal Main Shutoff Valves for Copper Manifolds:
1. Two piece body.
2. Body: Bronze.
3. Ball: 316 stainless steel ball, full port.
4. Seals: EPDM sealing elements.
5. Stem Seals: EPDM.
6. Lockable metal handle.
7. Press ends with Smart Connect feature.
8. Operating Temperature: 0 to 250 deg F

9. Maximum Operating Pressure: 200 psi.
10. 600 WOG.

L. Balancing Valves for Copper Manifolds
1. Body: Brass.
2. Ball: Plated brass.
3. Ball Seal: Teflon™.
4. Ball Spindle: Nickel plated brass.
5. Spindle O-rings: EPDM and Viton™.
6. Metering Spindle: Nickel plated brass.
7. Spindle O-ring: Viton™.
8. Working Temperature: 250 deg F.
9. Working Pressure: 250 psi

M. Mounting Brackets for Copper Manifold:
1. Bracket Material: Steel zinc-plated with rubber liners.

N. Zone Control Valve (ProPress x ProPress):
1. Body:
   a. Maximum Pressure Differential: 50 psi.
   b. Cv Rating 3/4" Valve: 4.0.
   c. Cv Rating 1" Valve: 8.5.
   d. Fluid Temperature: 32 to 212 deg F
   e. Stem Travel: 4mm.
   f. Body Material: Low zinc bronze, alloy C84400.
   g. Seat: Bronze, C84400. Integral part of valve body.
   h. Valve Disc: EPDM / Brass.
   i. Valve Spring: Stainless Steel.
   j. Valve Stem: Burnished 303 Stainless Steel.
   k. Packing: Double EPDM.
   l. Ratings: ANSI 250 per ASME B16-22-2013.

2. Motor:
   a. Voltage: 24 Volts.
   b. Maximum Inrush Current: 300 mA, for 2 minutes.
   c. Operating Power: 1 W.
   d. Closing/Opening Time: Approximately 3 minutes.
   e. Actuating Force: 21 lbs

3. Inlet / Outlet Connections:
   a. For Types K, L, and M hard copper tubing 3/4 inch or 1 inch and soft copper tubing 3/4 inch to 1 inch
   b. Housing: Copper or bronze.
   c. Smart Connect Feature.
   d. Sealing Element: EPDM.
   e. Tools: Manufacturer's special tools.

O. Zone Control Valve (ProPress x PEX Press):
1. Body:
   a. Maximum Pressure Differential: 50 psi.
   b. Cv Rating 3/4" Valve: 4.0.
   c. Cv Rating 1" Valve: 8.5.
   d. Fluid Temperature: 32 to 212 deg F

e. Stem Travel: 4mm.
f. Body Material: Low zinc bronze, alloy C84400.
g. Seat: Bronze, C84400. Integral part of valve body.
h. Valve Disc: EPDM / Brass.
i. Valve Spring: Stainless Steel.
j. Valve Stem: Burnished 303 Stainless Steel.
k. Packing: Double EPDM.
l. Ratings: ANSI 250 per ASME B16-22-2013.

2. Motor:
   a. Voltage: 24 Volts.
   b. Maximum Inrush Current: 300 mA, for 2 minutes.
   c. Operating Power: 1 W.
   d. Closing/Opening Time: Approximately 3 minutes.
   e. Actuating Force: 21 lbs

3. Inlet Connection (ProPress):
   a. For Types K, L, and M hard copper tubing 3/4 inch or 1 inch and soft copper tubing 3/4 inch to 1 inch
   b. Housing: Copper or bronze.
   c. Smart Connect Feature.
   d. Sealing Element: EPDM.
   e. Tools: Manufacturer's special tools.

4. Outlet Connection (PEX Press):
   a. Bronze Fittings: PEX Press Fittings manufactured from UNS C87700 copper alloy, meeting the requirements of ASTM F 877 tested as a system with ViegaPEX Barrier tubing or FostaPEX tubing.
   b. PEX Press Sleeve: Manufactured out of a 304 grade or better stainless steel, and have three view holes with an attached sleeve to ensure proper PEX tubing insertion.
   c. Attached sleeve fitting will incorporate a tool locator ring that shall be in place while making a proper press connection.
   d. PEX Press connection shall be made with a Viega supplied ratcheting PEX Press hand tool or PEX Press power tool.

P. Zone Control Valve (Sweat x PEX Press):
1. Body:
   a. Maximum Pressure Differential: 50 psi.
   b. Cv Rating 3/4-inch Valve: 4.0.
   c. Cv Rating 1-inch Valve: 8.5.
   d. Fluid Temperature: 32 to 212 deg F
   e. Stem Travel: 4mm.
   f. Body Material: Low zinc bronze, alloy C84400.
   g. Seat: Bronze, C84400. Integral part of valve body.
   h. Valve Disc: EPDM / Brass.
   i. Valve Spring: Stainless Steel.
   j. Valve Stem: Burnished 303 Stainless Steel.
   k. Packing: Double EPDM.
   l. Ratings: ANSI 250 and per ASME B16-22-2013.

2. Motor:
   a. Voltage: 24 Volts.

b. Maximum Inrush Current: 300 mA, for 2 minutes.
c. Operating Power: 1 W.
d. Closing/Opening Time: Approximately 3 minutes.
e. Actuating Force: 21 lbs .

3. Inlet Connection (solder):
   a. For Types K, L, and M hard copper tubing 3/4 inch or 1 inch and soft copper tubing 3/4 inch to 1 inch
   b. Yellow Brass: 3/4 inch to 1 inch as per ASME B16-22-2013 manufactured from UNS C85800 copper alloy.
   c. Sealing Gasket: Between Union and Valve Body; Black EPDM, peroxidically cured.

4. Outlet Connection (PEX Press):
   a. Bronze Fittings: PEX Press Fittings manufactured from UNS [C83600] [C87700] [C87710] copper alloy, meeting the requirements of ASTM F 877 tested as a system with ViegaPEX Barrier tubing or FostaPEX tubing.
   b. PEX Press Sleeve: Manufactured out of a 304 grade or better stainless steel, and have three view holes with an attached sleeve to ensure proper PEX tubing insertion.
   c. Attached sleeve fitting will incorporate a tool locator ring that shall be in place while making a proper press connection.
   d. PEX Press connection shall be made with a Viega supplied ratcheting PEX Press hand tool or PEX Press power tool.

2.5 PIPING SPECIALTIES

A. Cable Ties:
   1. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
   2. Minimum Width: 0.17 inch.
   3. Tensile Strength: 75 lb, minimum.

B. Floor Mounting Staples:
   1. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
   2. Minimum Thickness: 0.055 inch.
   3. Width: 0.962 inch.

C. Floor Mounting Clamps:
   1. Two bolts, steel, with corrosion-resistant coating and smooth finish without sharp edges.
   2. Minimum Thickness: 3/32 inch.
   3. Width: Minimum, wider than tubing.

D. Floor Mounting Tracks:
   1. Aluminum or plastic channel track with smooth finish and no sharp edges.
   2. Minimum Thickness: 1/16 inch.
   3. Slot Width: Snap fit to hold tubing.
   4. Slot Spacing: 2-inch intervals.

E. Climate Mat: Pre-engineered preassembled in slab radiant system.

1. Spacer Strip: Semi-rigid 1 inch wide by approximately 5 to 6 feet long plastic strips.
   a. Used with plastic, press-in-place, u-shaped clips to secure the tube every 4 feet along the run of tube at predetermined spacing.
   b. Plastic strip shall be used to secure the Climate Mat assembly to the sub-base prior to the concrete pour.
   c. Additional fasteners shall be used as needed.
2. ViegaPEX Barrier Tubing: Saline cross-linked high-density polyethylene per ASTM F 876/F 877.
   a. Tubing shall include oxygen diffusion barrier in accordance with DIN 4726.
   b. Tubing shall meet requirements of ANSI/NSF 14 and 61.
   c. Certified to UL 263 ULC S101 for floor and wall assemblies.
   d. Certified to ASTM E84 and ULC S102.2 Flame Spread (FS)/Smoke Developed (SD) (25/50).

F. Insulated Panel Foam-Plastic Board Insulation:
1. 2 inch floor slab insulation: 2 7/8 inch total thickness with 2 inches of solid EPS foam providing an R 10 and 25 psi compressive strength rating.
   a. Each panel to cover 8 sq. ft with an integral 10 mil polystyrene film providing a perm rating of 51 perms and a fastener for 3/8 inch 1/2 inch and 5/8 inch Viega PEX Barrier tubing, or 1/2 inch Fosta PEX tubing.
   b. Panels to have protrusions approximately 2.6 inches in diameter and a height of approximately 0.9 inches. Protrusions to be aligned in alternating rows 3 inches apart on center to allow for an accurate tube placement on a 3 inch grid system.
2. Flexural Strength in accordance with ASTM C 203-99, Method 1, Procedure A Modified with results as follows:
   a. Shell Covered Face in Tension: 35 psi maximum fiber stress.
   b. Exposed EPS Foam Insulation Face in Tension: 66 psi maximum fiber stress.
3. Compressive Resistance in accordance with ASTM C 165-00 Modified with results of 25 psi compressive resistance.
4. Density testing in accordance with ASTM D 1622-03 Modified with results as follows:
   a. Foam: 1.646 lb/cubic ft.
   b. Plastic Shell and Foam: 1.95 lb/cubic ft
5. Dimensional Stability testing in accordance with ASTM D 2126-04 7 day at minus 40 deg F and 7 day at 158 deg F, 97 percent RH, -0.4 percent change in length and -0.1 percent change in thickness.
6. Water Absorption testing in accordance with ASTM C 272-01 Modified resulted in 0.83 percent by volume absorbed.

G. Climate Panel:
1. Plywood: CCX fir plywood with an aluminum heat transfer sheet underneath.
2. Product Designation: CANPly Exterior/Interior Plywood.
3. Grade: Sheathing (CCX by PS1-95).
4. Glue: Bordens 2022 Phenol, Formaldehyde, Resin, Exterior Bond Type X.
5. Panels are to be used with 5/16 inch ViegaPEX Barrier Tubing.

H. Trak:
1. Extruded aluminum for radiant heating piping.
2. Minimum Thickness: 0.05 inch
3. 4 feet or 8 feet length with predrilled holes every 11.5 inches

4. Accommodate either3/8 inch or 1/2 inch pipe.

I. Heat-Emission Plates:
1. Formed aluminum suitable for radiant-heating piping.
2. Size: 5 inches wide x 19 inches long.
3. Minimum Thickness: 0.16 inch.
4. Slot Width: Snap fit to maintain pressure fit on tubing.

2.6 CONTROLS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Viega LLC; or a comparable product by one of the following:
1. Danfoss Inc.
2. Honeywell Building Solutions; Honeywell International, Inc.
3. Infloor Radiant Heating Inc.
4. IPEX USA LLC.
5. Oventrop Corporation.
6. tekmar; A WATTS Brand.

B. Digital Thermostat:
1. Control: Microprocessor control.
2. Accuracy: 0.2 deg F
3. Set Temperature Range: 41 to 99 deg F 0.5 deg F increments.
4. Environment Range: 32 to 122 deg F
5. Power Supply: 24 V +/- 10% 60 Hz 15 W max.
6. Output: TRIAC Output 24 VAC, 15 W max.
7. Optional Floor Sensor: NTC thermistor (10 K Ohms), 10 foot cable.
8. Floor Limiting Range: 50 to 104 deg F
9. Electrical Protection: Class II - IP30.

C. Heated-Panel Thermostat:
1. Remote bulb unit with adjustable temperature range from 50 to 104 deg F
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump or zone control valve.
3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant-panel temperature.
4. Stop pump or close zone control valves if heated-panel thermostat setting is exceeded.
5. Corrosion-resistant, waterproof control enclosure.

D. Set Point Control:
1. Remote sensor unit with adjustable temperature range from minus 40 to 248 deg F.
2. Snap action; open-on-rise, 2 SPDT dry contacts, 1/2 hp @ 120 VAC, 9.8 FLA, 58.8 LRA.
3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant-panel temperature.
4. Stop pump or close zone control valves if heated-panel setting is exceeded.
5. Corrosion-resistant, waterproof control enclosure.

E. Basic Heating Control Outdoor Temperature Reset Control:

1. Control: Microprocessor PID Control.
2. Approvals: CSA C US< meets ICES & FCC regulations for EMI/RFI.
3. Power Supply: 120 VAC +/- 10 percent 50/60 Hz 1300 VA.
4. Floating Output: 24 VAC 0.34 A 8 V.
5. Relays: 240 VAC 10 A 1/3 hp, pilot duty.
6. Sensors: NTC thermistor.
7. Remote bulb unit with adjustable temperature range from 35 to 100 deg F]<Insert temperature based on design>.
8. Operate based on outdoor air temperature. Control resets supply-water temperature inversely with outdoor-air temperature as follows:
   a. Low outdoor-air temperature, ranging from minus 60 to 32 deg F with high supply-water temperature 70 to 220 deg F
   b. High outdoor-air temperature, ranging from minus 60 to 32 deg F with low supply-water temperature 70 to 220 deg F.
9. Ambient Conditions: Indoor use only, 32 to 102 deg F, less than 90 percent RH non-condensing.

F. Precipitation and Temperature Sensor:
   1. [Microprocessor-based] control with automatic and manual override.
   2. Precipitation and temperature sensors shall sense the surface conditions of heated surface and shall be programmed to operate pumps as follows:
      a. Temperature Span: 32 to 95 deg F
      b. Idling Temperature Span: 20 to 95 deg F.
      c. Cold Weather Cut Out Span: minus 29 to 50 deg F.
      d. Start pump if ambient temperature is below set point and precipitation is detected.
      e. Start pump if ambient temperature is below set point and precipitation is not detected and system is intended to idle.
      f. Stop pump on detection of a dry surface plus time delay.
      g. Stop pump on detection of Cold Weather Cut Out Temperature.
   3. Minimum 5-A contactor to start pumps.
   4. Precipitation sensor shall be mounted in heated surface.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive radiant-heating piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

   1. Ensure that surfaces and pipes in contact with radiant-heating piping are free of burrs and sharp protrusions.
   2. Ensure that surfaces and substrates are level and plumb.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Install the following types of radiant-heating piping for the applications described:

1. Piping in Exterior Pavement: PEX.

3.3 INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings or coordination drawings.

B. Install radiant-heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.

C. Connect radiant piping to manifold in a reverse-return arrangement.

D. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.

E. Install manifolds in accessible locations or install access panels to provide maintenance access as required in Section 083113 "Access Doors and Frames."

F. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties" for pipes and connections to hydronic systems and for glycol-solution fill requirements.

G. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Section 078413 "Penetration Firestopping."

H. Piping in Exterior Pavement:

1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
2. Space cable ties a maximum of 18 inches o.c. and at center of turns or bends.
3. Maintain 3-inch minimum cover.
4. Install a sleeve of 3/8-inch- thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig pressure in piping during concrete placement and continue for 24 hours after placement.

I. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

J. After system balancing has been completed, mark balancing valves to permanently indicate final position.

K. Perform the following adjustments before operating the system:

1. Open valves to fully open position.
2. Check operation of automatic valves.
3. Set temperature controls so all zones call for full flow.
4. Purge air from piping.

L. After concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant-heating system as follows:

1. Start system heating at a maximum of 10 deg F above the ambient radiant-panel temperature and increase 10 deg F each following day until design temperature is achieved.
2. For freeze protection, operate at a minimum of 60 deg F supply-water temperature.

3.4 FIELD QUALITY CONTROL

A. Prepare radiant-heating piping for testing as follows:

1. Open all isolation valves and close bypass valves.
2. Open and verify operation of zone control valves.
3. Flush with clean water and clean strainers.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Radiant-heating piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Protect hydronic piping system from damage during construction.

End of Section

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Section 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The General and Supplement Conditions and General Requirements and Division 1 Specification sections shall apply to the work under this section of the Specifications as if printed herein.

B. Where General and Supplement Conditions and General Requirements clauses are repeated in these Specifications, it is to call special attention to them, or as a further qualification. No General and Supplement Conditions and/or General Requirements clause referring to the work of this Section shall be considered waived unless specifically stated herein.

C. Unless otherwise shown on the Contract Drawings, or unless otherwise specified in other Sections of these Specifications, the requirements specified in this Section are applicable to all electrical work of this Contract. Additional requirements applicable to individual Sections of these Specifications are specified in those Sections, or are shown on the Contract Drawings.

D. The Specifications and Contract Drawings shall form part of the Contract Documents.

E. Refer to Section 018113 for Sustainability Design Requirement

1.2 SUMMARY

A. Provide all labor, materials, supplies, tools, machinery, equipment, scaffolding, transportation, rigging, storage, utilities, supervision and required permits and licenses necessary to complete the electrical work under this contract.

B. Provide a complete working electrical installation with all equipment called for in proper operating condition. Documents do not undertake to show or list every item to be provided. When an item not shown or listed is clearly necessary for proper operation of equipment that is shown or listed, provide the item, which will allow the system to function properly at no increase in Contract Price.

C. Coordinate the electrical work with the work of the other trades so as to resolve conflicts without impeding job progress or the construction schedule.

D. Examine all Contract Documents including these for other trades in order to determine the extent of the Work required to be completed under this Section. Failure to examine all Contract Documents for this project will not relieve this contractor of the responsibility to perform all the Work required for a complete, fully operational and satisfactory installation.

E. Bidders are deemed to be aware, on the basis of the background and experience, of materials, which may be required in the discharge of their responsibilities, even though unspecified. Claims for extras for unspecified shoring or supporting materials will not be considered if the need for such materials would have been reasonably obvious to the bidders skilled and experienced in the work to be done and the submittal of a bid shall be deemed a waiver of any such claims.

F. Provide notice with bid proposal of any concrete or structural work required by this Section that is not indicated on the Structural or Architectural Drawings.

1.3 CODES, STANDARDS, FILING AND PERMITS

A. The Electrical installation shall comply with the latest revised versions of all applicable laws, rules, regulations, standards, codes and ordinances of the federal, state and local authorities having jurisdiction and other requirements specified in other Specifications and Contract Drawings.

B. If any of the provisions of the laws, rules, regulations, standards, codes, ordinances and requirements of the Contract Drawings or Specifications is in conflict with one another, the most stringent requirements shall govern.

C. Nothing in the Contract Drawings or Specifications shall be construed to permit Work not conforming to the applicable laws, ordinances, rules, and regulations. It is not the intent of the Contract Drawings or Specifications to repeat the requirements of codes except where necessary for completeness or clarity. Any modifications required by the above said authorities having jurisdiction shall be made without additional cost to the Owner. Where Contract Drawings and Specifications requirements are in excess of the rules, regulations and code requirements, and are permitted under the code, the Contract Drawings and Specifications shall govern.

D. All materials and equipment, materials and methods shall comply with all applicable requirements of laws, codes, ordinances, legislations, etc., of all federal, state and local authorities whether listed on the contract documents or not.

E. Obtain the required permits from the local authorities for this work and pay for all fees required by the local, State, and Federal authorities for permits, inspections and review, including special agency construction and operating permits. Make corrections in the work as required by the Owner's Representative or Inspector to pass all such regulations.

F. The Contractor shall be responsible for filing drawings, inspection arrangement with authorities having jurisdiction and local Utilities. The Contractor shall be responsible for all related fees.

1.4 REFERENCES

A. New York State Uniform Building Code (NYBSB), which is an amended version of the 2018 International Building Code (IBC)

B. 2017 Edition of NFPA 70, National Electric Code, as referenced by NYSBC Chapter 35.

C. New York State Uniform Fire Code (NYSUFC), which is an amended version of the 2018 International Building Code (IFC)

D. New York State Energy Conservation Construction Code (NYSECCC), which is an amended version of the 2018 International Energy Conservation Code (IECC).

E. 2018 NYSBC Chapter 11 and Appendix E. 2009 Edition of ICC A 117.1, Accessible and Usable Buildings and Facilities. 2010 ADA Standards for Accessible Design

F. American National Standards Institute (ANSI).

G. Environmental Protection Agency (EPA)

H. Electrical Industries Association/Telecommunication Industries Association (EIA/TIA)

I. Factory Mutual (FM)

J. Illuminating Engineering Society (IES).

K. Institute of Electrical and Electronics Engineers (IEEE).

L. National Electrical Code (NEC-NFPA70).

M. National Electrical Manufacturer's Association (NEMA).

N. National Fire Protection Association (NFPA).

O. National Electrical Contractors Association (NECA)

P. InterNational Electrical Testing Association (NETA)

Q. National Uniform Seismic Installation Guidelines (NUSIG)

R. Underwriters' Laboratories (UL).

S. Occupational Safety and Health Administration (OSHA)

1.5 DEFINITIONS

A. For purposes of these Specifications the following definitions apply:

1. “ARCHITECT”: the Architect of record.
2. “ENGINEER”: the Engineer of record.
3. “CONTRACTOR”: the individual, partnership or corporation to whom the Contract for the work has been awarded.
4. “PROVIDE”: to “Furnish” and “Install”.

5. "INSTALL": to join; unite; fasten; link; attach; set up or otherwise connect together; complete, tested, and ready for normal satisfactory operation.
6. "FURNISH": to supply all materials, labor, equipment, testing apparatus, controls, tests, accessories, and all other items customarily required for the proper and complete application.
7. "AS DIRECTED": as directed by the Owner's Representative
8. "CONCEALED": embedded in masonry or other construction, installed below slabs, behind wall furring or within double partitions, or installed within hung ceilings.
9. "SUBMIT": submit to the Owner's Representative for review.

1.6 WORK INCLUDED

A. The Work specified in this Division includes but is not limited to the following systems, equipment, and services:

1. Switchboards, Distribution, and panelboards for lighting and power.
2. Feeders, busway, sub feeders, and branch circuiting for light, power and control wiring, including connections to all service switchboards, distribution switchboards, transfer switches, panelboards, transformers, motor starter groups, motor control equipment, disconnect devices, outlets, motors and equipment included in these Specifications or indicated on contract drawings.
3. Furnishing and installation of lighting equipment, lighting fixtures, lamps, contactors, lighting and plug load control systems, etc.
4. Installation and testing of lighting equipment and controls.
5. Telecommunications empty raceway system.
6. Complete electrical grounding system.
7. Labor and/or standby assistance in commissioning the control and instrumentation systems provided with Building Automation and Temperature Controls Section of the Specification.
8. Connection of all equipment specified under other Divisions and/or supplied by the Owner.
9. Remove the protective coverings on the lighting fixtures when required by the heating, ventilating and air conditioning air-balancing subcontractor.
10. Miscellaneous items as required for complete and functioning systems as specified herein and indicated on the Drawings.
11. Provide all excavation and back-fill required for Work of this Division.
12. Furnish and set all sleeves complete with seals and firestops as specified herein and as required by the Authority having jurisdiction for the passage of conduit, etc. through structural steel, decking, masonry and concrete walls and floors, drywall construction, any other rated construction assembly, and elsewhere as will be required for the proper protection of each raceway passing through a wall, floor, etc. Coordinate the work with the work of other Trades in order to properly expedite and perform the work. Furnish shop drawings showing the size and location of all required holes through the concrete floors and walls.
13. Participate in and assist in the testing, operation and commissioning of all electrically powered equipment as required during the performance testing and startup of the work of other Sections. Refer to other Sections for additional requirements.

14. Instruments as required for operating and testing the various systems shall be furnished and installed complete as specified herein.
15. Owner's personnel shall be fully instructed regarding operation and maintenance of the entire installation and complete printed or typed instruction booklets shall be provided covering maintenance, operation, and adjustment of each piece of equipment. Spare parts lists for each piece of equipment shall be furnished.
16. Complete all tests required by all rules, regulations, etc. of all authorities having jurisdiction and prepare, complete and file all forms, tabulations, plans, etc., including Controlled Inspections, pertinent thereto with the referenced authorities and accomplish such work with personnel of proper caliber, in particular Professional Engineers, where so required.
17. Participate in and provide labor for “off hour” testing of equipment and systems as required by working conditions or by the Authorities Having Jurisdiction to obtain all “Temporary Certificate of Occupancy (TCO)” and final “Certificate of Occupancy”.
18. Patching or replace all fireproofing if it is damaged or removed during the installation of the Electrical Work.
19. Furnish required access doors in general construction for access to equipment and systems specified in this Division.
20. Power and empty raceway system for the security system components (refer to Security Consultant’s drawings and specifications).
21. Conduit, raceways, ladder racks, sleeves, etc., for the telecommunication systems.
22. Power and empty raceway system for the Audio Visual system (Refer to Audio Visual drawings and specifications.

1.7 SUBMITTALS

A. Submit detailed and fully coordinated shop drawings showing all conduit routes, equipment with nameplate, devices and pull boxes for each floor including all the Electrical Rooms. The Electrical Rooms shall be shown with large-scale layout shop drawings.

B. Submit manufacturer’s data, shop drawings and samples as noted of all proposed equipment including but not limited to the following:

Switchboards	Panelboards
MV Switchgear	Automatic Transfer Switches
Disconnect switches	Fire Alarm System
Transient Voltage Surge Suppressor	Circuit Breakers
Luminaries	Wiring Devices
Lighting and Plug Load Control System	Routing of all Conduit 2″ & Above
Grounding Equipment	Layout of all Electrical Rooms
Battery Equipment	Metering

1. Additional requirements may be present in individual specification sections. The Contractor is also responsible for complete submittals based on the requirements in each individual specification section.

C. Submit detailed and fully coordinated large-scale layout shop drawings showing the sections of all congested areas to show relative position and spacing of the effected elements.

D. The large-scale layout shop drawings shall be a minimum of 3/8 in. equal to 1 ft. scale.

E. Submit calculations where required by the Specifications or the Contract Drawings.

F. Submit detail designs for seismic restraint and support for conduits and equipment. The designs shall be certified and sealed by a Professional Engineer licensed in the State in which the work is to be performed.

G. Submit certified test reports and trip setting of overcurrent and overload devices where required by the Specifications or the Contract Drawings.

H. All symbols and designations used in preparing Record and Coordination Drawings shall match those used in the Contract Drawings.

I. Prior to Final Acceptance, the following data shall be furnished to the Owner's Representative:

1. Record Drawings.
2. Coordination Drawings
3. Operation and Maintenance Manuals
4. Manufacturer's Data of the equipment and devices installed

J. The commissioning process requires Submittal review simultaneously with Engineering review. Division 1 is alerted to the Submittal review requirements in Section 019113.

1.8 QUALITY ASSURANCE

A. All workmen performing under this Division shall be skilled workers of the trade involved. Where specialty work, such as splicing or welding are required, submit proof of training, experience and work history for each workman, for review by the Owner's Representative. Only properly qualified and certified workmen shall perform specialty work.

B. Only workmen previously approved by the Owner shall provide work on medium-voltage equipment. Refer to the medium-voltage cable specification 260513 for details.

C. All electrical work shall be performed by an electrical contractor licensed in the state (and the city as required) in which the work is to be performed.

D. All electrical materials and equipment for which there is a nationally recognized standard shall bear the conformance labeling of an independent testing laboratory, such as Underwriters Laboratories Inc., Factory Mutual, ETL or other agency recognized by the local Authority having jurisdiction.

E. Carcinogenic material, including Asbestos shall not be furnished or installed.

F. All calculations required by this and other various Sections of these Specifications, or as shown on the Drawings, shall be certified and sealed by a Professional Engineer licensed in the state in which the work is to be performed, and shall be submitted to the Owner's Representative for review.

G. With the exceptions as specified and/or indicated on the Drawings or in the Specifications, the Contractor shall apply, install, connect, erect, use, clean, commission and condition manufactured articles, materials, and equipment per Manufacturer's current printed instructions and recommendations. Copies of such printed recommendations shall be kept at the Project site and made available as required.

H. Where the manufacturer's recommendations conflict with the Contract Documents, the conflict shall be brought to the attention of the Owner's Representative's immediately.

1.9 GUARANTEE

A. Submit a single guarantee stating that all portions of the work are in accordance with Contract Documents. Warrant all work against faulty and improper material and workmanship for a period of one year from date of substantial completion, except that where guarantees or warranties for longer terms are specified herein, such longer term shall apply. At no additional cost to Owner, within 24 hours after notification, correct any deficiencies, which occur during the warranty period (including all parts, material, labor, etc.), all to the satisfaction of the Owner or his designated representative. In default thereof, the Owner may have such work done and charge all costs to the Contractor. This Contractor shall require similar guarantees from his Subcontractors.

B. During the warranty period, the Contractor shall guarantee the following in a form satisfactory to the Owner:

1. All equipment will develop capacities and performance characteristics specified.
2. The systems shall operate without malfunction.

C. The start of the Contractor's warranty period shall commence on the issue of a "Certificate of Substantial Completion", by the Owner's Representative for each item of material, equipment, or system.

D. The Subcontractor shall confer with the Construction Manager prior to the bid date concerning the project schedule and determine if there is a need to operate any items of equipment or systems for temporary light, power, heating and/or cooling or other reasons prior to "Substantial Completion". All required extended warranty costs for equipment, materials, and systems shall be included in the Contractor's bid.

E. Warrant that all components, subsystems and systems will perform their specified functions from the date of turnover and commercial operation through the useful life of the system. In the event components fail for any reason, be responsible to repair, replace and reimburse the Owner for all costs associated with the component, subsystem or system that failed to perform the specified function.

1.10 SCHEDULING

A. The following is a summary of the scheduling milestones described in the text of the Specifications. The Contractor shall start on or schedule the following upon receiving notice to proceed.

1. Immediately upon award of this Contract, this Contractor shall have a pre-construction meeting with the Owner's Representative.
2. On or before three (3) weeks after notice to proceed, submit a complete, typed list of the subcontractors, equipment manufacturers and suppliers they intend to use to the Owner's Representative for review.
3. On or before six (6) weeks after notice to proceed, prepare an index of all his Electrical shop drawings and brochures for the Project.
4. As requested by the Construction Manager, the Contractor shall submit "Coordination Drawings" to the Owner's Representative for review.
5. As requested by the Construction Manager, the Contractor shall provide a detailed schedule of completion indicating when each system is to be completed and outlining when tests will be performed.
6. Submit proposed test procedures, recording forms and test equipment for review by the Owner's Representative a minimum of six (6) weeks prior to execution of testing. Any testing performed prior to the above may be considered invalid and may be required to be re-done at the Contractor's expense.
7. Submit six (6) final copies of the Operation and Maintenance books to the Owner's Representative for review at least ten (10) weeks before Final Review of the Project.

1.11 SPACE CONSTRAINT

A. The equipment selections used in the preparation of the Contract Documents will fit into the physical spaces provided and indicated, allowing ample room for access, servicing, removal and replacement of parts, etc. Adequate space shall be allowed for clearance in accordance with Code requirements, the requirements of the Authorities Having Jurisdiction, and the equipment manufacturer's recommendations.

B. In the preparation of Drawings, a reasonable effort to accommodate acceptable equipment manufacturer's space requirements has been made. However, since space requirements and equipment arrangement vary according to each manufacturer, the responsibility for initial access, maintenance access, code required access, and proper fit rests with the Contractor.

C. Physical dimensions and arrangements of equipment to be installed shall be subject to the Owner's Representative's review.

D. Wherever possible, electrical equipment distribution and branch lines shall be installed tight to structure.

1.12 DRAWINGS AND COORDINATION WITH OTHER WORK

A. Contract Drawings

1. Drawings are essentially diagrammatic, intended to convey the scope of work and to indicate the desired location or arrangement of equipment, devices, conduit runs, outlets, etc and are to be followed as closely as possible. Judgment must be exercised in executing the Work so as to secure the best possible installation in the available space and to overcome local difficulties due to space limitation or interference with structural conditions.
2. Drawings indicate, diagrammatically, the routes of duct banks and conduit system, unless specifically dimensioned, and do not indicate the required pull boxes, cable support boxes, fittings, seismic restraint, supports or similar items required for a complete system
3. Exact routing of wiring and locations of outlets, panels, equipment, devices, luminaires, etc., shall be governed by structural conditions, obstructions and existing conditions. Owner's Representative reserves right, at no increase in cost, to make any reasonable change in locations of electrical items, exposed at ceiling and/or on walls, to group them into orderly relationships and/or increase their utility.
4. The Contractor shall follow the Drawings in laying out the Work and check drawings of all trades to verify spaces in which Work will be installed. Maintain maximum headroom in all areas. Where space conditions appear inadequate, the Owner's Representative shall be notified before proceeding with the installation.
5. Work not shown on the Drawings but called for in the Specifications, or vice versa, shall be provided by the Contractor without additional expense to the Owner.
6. Certain materials will be furnished, installed, or furnished and installed, under other Sections of the Contract Documents. Examine the Contract Documents to ascertain these requirements
7. Where variance occurs between the Drawings and Specifications, or within either document itself, the items or arrangement of better quality, greater quantity, or higher cost shall be included in the contract price. The Contractor shall request clarification in writing from the Owner's Representative on which item and manner in which the Work shall be installed.
8. Equipment's location and dimensions shown on the Drawings is approximate of a typical equipment of the class indicated and has been coordinated for structural penetrations, electrical requirements, operating and service requirements, and physical size with regard to the space where the equipment is shown. Other specified manufacturers of this equipment will be acceptable contingent on the Contractor providing a complete installation and maintaining full responsibility to provide, at no additional cost, any modifications to the structure or electrical service that are required to properly install, operate, and service the equipment. These modifications shall not include additional area for the equipment unless agreed to by the Owner's Representative.
9. Locations shown on Architectural Reflected Ceiling Drawings, Architectural Floor Plans or on wall elevations shall take precedence over electrical plan locations. For roughing out devices, the Contractor shall refer to the Architectural Drawings.

B. Coordination:

1. Work out all "tight" conditions involving Work under this Division and Work in other Divisions in advance of installation. If necessary, and before Work

proceeds in these areas, prepare supplementary Drawings under this Division for review, showing all Work in "tight" area. Provide supplementary Drawings and additional Work necessary to overcome "tight" conditions.

2. Carefully check space requirements with other Sections of the Contract Documents to insure that all material can be installed in the spaces allotted thereto.
3. Transmit to other Trades information required for work to be provided under other Sections such as space for access to pull boxes, cable support boxes, control wiring and connections, access doors in ample time for installation.
4. The Construction Manager and all Trades shall coordinate the installation of equipment, conduit, busway, ductwork, piping, cable, cable trays, etc., with the installation of luminaires, special ceiling construction, air distribution equipment and the structure. Provide additional rises, drops, offsets and pullboxes as required. If, after installed, new conduit, busway, ductwork, piping or cable is found to be in conflict with the architecture, structure, or other trade Work which is either existing or shown on the Contract Documents, the conduit, busduct, ductwork, piping or cable shall be relocated without additional cost to the Owner.
5. Wherever work interconnects with work of other trades, coordinate this work to insure that other trades are advised of the information necessary so that they may properly install all the necessary connections and equipment. Identify all work items in a manner that the work of other trades may know where to install access doors and panels.
6. Furnish and set all sleeves for passage of the electrical service and distribution, and telecommunication services through structural masonry and concrete walls and floors and elsewhere as will be required for the proper protection of each conduit passing through building surfaces. Coordinate this work with the Construction Manager in order to properly expedite and perform this work and provide fireproofing in accordance with these Contract Documents.
7. A planned sequence of operation is required to properly install the complete systems. It shall be the responsibility of Contractor to coordinate, protect and schedule its work with other trades in accordance with the construction sequence.
8. Architectural drawings shall be checked for ceiling height requirements. Where no ceiling height is stated, request direction from Owner’s Representative prior to commencing work.
9. Field drilling, cutting and/or reinforcing of holes in structural metal deck required for work specified in this Division shall be coordinated through the Owner’s Representative. All such drilling, cutting and reinforcing costs shall be included as work of the Contract Documents.
10. Differences or disputes concerning coordination, interference or extent of Work between trades shall be decided by Contractor. Contractor’s decision, if consistent with Contract Documents requirements, shall be final.
11. Coordinate electrical power and control wiring requirements of mechanical equipment specified in Division 23.
12. Coordinate electrical power and control wiring requirement of Building Management System and Security System with corresponding documentation.
13. Equipment rough-in locations shown on the Drawings for equipment furnished by Owner and for equipment specified under other Divisions are approximate only. Obtain exact rough-in locations from following sources:

a. From shop drawings for Contractor-furnished and installed equipment.
b. From Owner's Representative for Owner-furnished Contractor-installed equipment.

14. Where conflict exists between rough-in shown on drawings and that shown or required by equipment to be installed, obtain clarification from Owner's Representative and provide rough-in as directed.
15. Provide templates, information and instructions to other Divisions to properly locate holes and openings to be cut or provided for the Work.
16. Cooperate and confer with other trades as to locations of their materials and equipment before erecting work, so as to avoid interference as much as possible, and in such a manner that will in no way retard progress of construction. In the event that interferences develop, the Contractor's decision will be final as to which trade shall relocate its work, and no additional compensation will be allowed for the moving of piping, ductwork, conduit or equipment to clear such interferences.
17. Coordinate with Owner as to their requirements for service connections and provide all necessary materials, labor and testing.
18. Furnish to appropriate trades, shop drawings, catalog sheets and instructions necessary for construction of concrete bases, concrete encasement, anchor bolts, and other construction required to accommodate installations under other Sections.
19. Before installing electrical work, all pertinent drawings shall be studied and precise information obtained from the architectural schedules, scale drawings, large scale and full size details of finished rooms, reviewed shop drawings or from the Owner's Representative. It shall be understood that even after all the coordination there may be cases where some electrical work, due to the unforeseen site conditions, may required to be relocated within 10 feet from the location shown. In such cases, the Contractor shall relocate the electrical work if so directed by the Owner's Representative at no increase in cost. Make any necessary adjustment of the work to fit conditions for luminaires, switches, fire alarm devices and for outlets occurring in glazed tile, block, wood paneling or other special finish material in order that all boxes shall be flushed with finish and be centered properly. In centering outlets make due allowance for overhead piping, ducts, window and door trim, variations in thicknesses of furring, plastering, etc., as erected, regardless of conditions which may be otherwise shown on small scale drawings. Electrical work incorrectly located shall be properly relocated without expense to the Owner
20. Locate local switches, which are shown near doors at the strike side of the door, unless specifically noted on plans to be beyond the open door.
21. In Mechanical Rooms, Electric Rooms, Elevator Machine Rooms, Pump Rooms, Communications Rooms, etc., light fixture arrangement shall be adjusted to suit the final coordinated equipment, duct, conduits, racks and piping layouts. Fixtures shall be mounted approximately 9 feet 0 inches above the finished floor, unless otherwise noted on the Drawings.
22. Coordinate all components and aspects of the work, in order to minimize power shutdowns to the power distribution systems. Should any part of the Work require an "off-hours" shutdown, supply temporary services or feeders to maintain operation of the existing systems and equipment.

C. Coordination Drawings

1. The Contractor shall produce a complete set of the “Coordination Drawings” showing electrical, mechanical, plumbing, fire protection, structural and architectural components for the project.
2. The Drawings shall indicate the equipment actually purchased and the exact location of the equipment and the exact routing and elevations for all lines such as piping, busway, conduit, ductwork, etc. All dimensions shall be referenced to building structural centerlines.
3. All Contract Drawing space allocations shall be maintained, such as ceiling height, chase walls, equipment room size, etc., unless prior written authorization is received from the Owner’s Representative to change them.
4. The Drawing preparation and completion shall comply with the requirements of the project construction schedule.
5. The Contractor's "Coordination Drawings" indicating piping, conduit, busway, and equipment support points and loads exceeding 500 lb. imposed on the building structure shall be submitted to the Owner’s Representative for review. The elevation, location, support points, static, dynamic and expansion forces and loads imposed on the structure at support, and anchor points, and the size of all lines shall be indicated.
6. All beam penetrations and slab penetrations shall be indicated and sized and shall be coordinated. All work routed underground or embedded in concrete shall be indicated by dimension to column and building lines and shall be coordinated. This requirement for "Coordination Drawings" shall not be construed as authorization for the Contractor to make any unauthorized changes to the Contract Drawings.
7. Prepare large scale detailed layout Drawings showing locations of equipment, conduit runs, panels, and all other elements of electrical systems where required by other Sections of this Division, plus sections of all congested areas to show relative position and spacing of affected elements. All symbols and designations used in preparing Record Drawings shall match those used in Contract Drawings.
8. The Work shall be installed in accordance with the shop drawings and the “Coordination Drawings”. If the Contractor allows one trade to install their work before coordinating with the work of other trades, the Contractor shall make necessary changes to correct the condition without extra cost to the Owner.
9. Each "Coordination Drawing" shall be completed and signed off by the other trades and the Contractor prior to the installation of the work in the area covered by the specific coordination drawing.

1.13 SHOP DRAWINGS AND SAMPLES

A. All shop drawings and samples shall be identified as follows

1. Date of submittal.
2. Title of project.
3. Name of Contractor and date of his approval.
4. Name of Subcontractor or supplier and date of submittal to Contractor.
5. Number of submission.

6. Any qualification, departure or deviation, item by item, from the requirements of the Contract Documents.
7. NEMA reference, IEEE Standard, MEA number where required.

B. The term "shop drawings" shall include layout, detail, and assembly drawings, diagrams, schedules, catalogue sheets, printed descriptive matter, and tabular and graphical presentations of operating and performance data that describe work required by the Contract Documents.

C. No part of the work shall be started in the shop or in the field until the Owner's Representative has reviewed the shop drawings and samples for that portion of the work and provided the response required. Thereafter, the work shall be executed in accordance with the Contract Documents and the indicated status of the reviewed shop drawing.

D. Shop drawings and samples shall be submitted for review sufficiently in advance of the scheduled start of the work in the shop or in the field to allow ample time, in consideration of the number and complexity of the drawings in the submittal, for the Owner's Representative to make an orderly review. No extension to complete the work will be granted to the Contractor by reason of his failure in this respect.

E. The Contractor shall carefully check shop drawings and samples, including those received by them from Subcontractors and material personnel, for accuracy, completeness of required information and conformance with the Contract Documents. Shop drawings found to be inaccurate, incomplete or not in conformance with the Contract Documents shall be corrected and/or appropriately annotated before being submitted to the Owner's Representative for review.

F. Each submitted shop drawing shall bear the Contractor's stamped and signed certification (i.e., by the Project Manager) that the work has been checked for all related job conditions, for maintenance of architectural conditions, and coordinated with the shop drawings of other trades for interrelated work, as required for the proper and complete performance of the work. No shop drawing submittal will be reviewed without this certification.

G. While the Contractor shall have access to the Engineer's drawings, neither the Engineer's drawings nor electronic files nor any other reproduced copy of the Engineer's drawings at any scale shall be used by the Contractor to generate any shop drawings. Shop drawings shall be completely drawn at the appropriate scale for any purpose on the project.

H. Each shop drawing and sample submitted for review shall be accompanied by a letter of transmittal, and shall be identified by the project title, Contractor's name, and a reference to the related part of the Contract Documents.

I. Shop drawings for manufactured material and equipment shall include model numbers, dimensioned drawings, operating weights, material specifications, operating features and controls wiring diagrams, performance characteristics, service procedures, including clearance requirements for maintenance work, and conformance to specified Codes and standards. Note that in addition to these requirements, other specific

submittal data, and forms of data submission, are required by the Contract Documents for particular items of equipment and material.

J. Shop drawings for Switchboard Rooms, electric closets, and for conduit and similar distribution services shall show by dimension the exact size and location of each element of the system in both the horizontal and vertical plane, as well as relationship to the building structure, architectural construction, equipment, and the work of other Trades. Shop drawings shall clearly show where doors providing access to equipment will be required in finished construction. Pads, foundations, anchorages, supports and attachments to the building structure, where required for the installation of the work shall be shown in layout and detail with sizes, dimensions, materials and methods of construction noted. The work described in any shop drawing submission shall be carefully checked by this Contractor for all clearances, including those required for maintenance, servicing equipment removal, field conditions, maintenance of architectural conditions and proper coordination with all Trades on the job. Each submitted shop drawing shall include a certification by the Contractor that all related job conditions have been checked and that no conflict exists. No shop drawing submission will be reviewed without such certification.

K. Ensure clean pathways including use of elevators, hoists, cranes / gantries for the delivery of equipment to designated locations. Coordinate all openings required for equipment passage with other trades.

L. Samples shall be identical in all respects to the material which is to be installed or applied in the execution of the work, and shall be of sufficient size or quantity to permit proper evaluation and review. Manufacturer's descriptive labels and printed application instructions which are normally attached to the material or its packaging shall be furnished with the sample. Samples shall be submitted for review when requested by the Owner’s Representative.

M. Within the agreed upon time period but no later than three weeks after award of the Contract, the Contractor shall submit for the Owner’s Representative's review, a list of the manufacturers products and services he proposes to use for the work. .

N. Within the agreed upon time period but no less than six weeks after award of the Contract, the Contractor shall submit a schedule listing all shop drawings and samples with the projected date that each item will be submitted to the Owner’s Representative for review.

O. Review of drawings and other material submitted shall not be construed as a complete check or constitute a waiver of the requirements of the Contract Documents. This review shall not relieve the Contractor of the responsibility to fit the proposed materials to the spaces provided, and to effect necessary rearrangement or construction of other Work.

1.14 RECORD DRAWINGS

A. The Contractor shall maintain on a daily basis at the Project site a complete set of "Record Drawings". The "Record Drawings" shall consist of a set of blueline prints and AutoCAD files of the Contractor Coordination Drawings for this Section. The prints shall

include the updated AutoCAD files, which shall be periodically electronically updated to show the precise location of all buried or concealed work and equipment, including embedded piping and valves, and all changes and deviations in the Electrical work from that shown on the Contract Documents. This requirement shall not be construed as authorization for the Contractor to make changes in the layout or work without written definite instructions from the Owner's Representative. Prior to commencing work, the Contractor shall obtain from the Owner's Representative a set of AutoCAD Drawings on CD-ROM to be used only to produce the Contractor's Coordination Drawings. The continuously updated coordination drawings shall be used to produce the final "Record Drawings" which shall be delivered to the Owner in AutoCAD electronic format upon Project completion. The Contractor shall give to the Owner's Representative the written release, included as part of this Section in Appendix B, signed by a corporate officer of the Contractor prior to receipt of the Engineer's diskettes.

B. Dimensions shall clearly and accurately delineate the work as installed; locations shall be suitably identified by at least two dimensions to permanent structures.

C. Upon completion of the Work, the Contractor shall certify all "Record Drawings" on the front lower right hand corner adjacent to the above marking with a rubber stamp impression or an AutoCAD image that states the Project name, the Contractor's name, the area covered and the date.

D. Prior to final acceptance of the Work of this Section, the Contractor shall submit properly certified "Record Drawings" to the Owner's Representative for review and shall make changes, corrections, or additions as the Owner's Representative may require to the "Record Drawings". After the Owner's Representative's review, and any required Contractor revisions, the "Record Drawings" shall be delivered to the Owner on CD-ROM in AutoCAD format for the Owner's use.

1.15 SUBSTITUTIONS

A. Specified products or equipment mean those named on the manufacturer list in the Specifications. All other manufacturers are considered substitutions.

B. Proposed substitutions for material and equipment required by the Contract Documents shall be submitted to the Owner's Representative for review at the time when the Contractor submits a list of the manufacturers whose products and services he proposes to use for the work. After the expiration of this period, substitutions for material or equipment shall not be proposed or requested in shop drawing and sample submittals, and the Contractor will be required to execute the work in accordance with the provisions of the Contract Documents

C. Submittals proposing or requesting substitutions shall be expressly identified as such in a letter of transmittal, with the reasons for requesting the substitution stated and a clear table of comparison listing pertinent features of both first named and proposed materials including material of construction, overall length, width, height dimensions, space required for tube replacement or maintenance access, motor type, horsepower, voltage, phase service factor, noise levels and performance data. Review of proposed substitution will not be made until receipt of satisfactory comparison tabulation.

D. The judgment of the Owner's Representative with respect to the adequacy and acceptability of a proposed substitution shall be final and binding on the Contractor.

E. Any additional work required by other trades as a result of a substitution shall be covered under this Contract. Submittals for this purpose shall be complete in every respect, shall conform to all the information requirements for shop drawing and sample submittals, and shall include, at no cost, the necessary revisions to other related work required by the Contract Documents

F. When a substitution is proposed, the Contractor shall be responsible to ensure that the performance and quality of the scheduled or specified equipment is met including all accessories.

1.16 DELIVERY, STORAGE, HANDLING AND PROTECTION

A. Include all shipping, delivery, hauling, hoisting, shoring, and placement in the building of equipment and materials specified herein. The Contractor shall be responsible for the timely delivery of equipment to the project site as required by the construction schedule. If any item of equipment is received prior to the time it is required, the Contractor shall be responsible for its proper storage and protection until such time as it may be required. The Contractor shall pay for all costs of storage in a bonded warehouse.

B. If any item of equipment is not delivered to or installed at the Project site in a timely manner as required by the Project construction schedule, the Contractor shall be solely responsible for disassembly, re-assembly, manufacturer's supervision, shoring, general construction modifications, delays, overtime costs, etc. No additional cost or delays shall be incurred by the Owner.

C. All other trades' equipment, materials and work shall be protected from damage in areas where electrical work is being carried out. All damage shall be corrected in a manner acceptable to the Owner without additional cost to the Owner.

D. The Contractor shall be responsible for all work, materials and equipment until finally inspected, tested and accepted; protect work against theft, injury or damage; and carefully store material and equipment received on site which is not immediately installed. All the equipment, materials and the work shall be covered and protected during construction to prevent entry of dust, dirt, obstructing material and to prevent damage due to weather, water, spray-on fireproofing, construction debris, etc., in a manner acceptable to the Owner.

E. All equipment, materials, devices, etc stored off site and delivered to the site must be kept in the manufacturers' original unopened protective packaging with shipping bars, retainers and positioning devices in place until installation. Store all items subject to moisture damage in dry and heated space with factory covering in place.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Equipment and materials furnished shall be new and unused, prior to this installation, first grade commercial quality and shall be essentially the standard cataloged products of a manufacturer regularly engaged in the manufacture of the products. Only those items specifically shown on the Drawings as existing, relocated or Owner furnished shall be reused in this installation. Rebuilt or remanufactured equipment will not be permitted.

B. Since manufacturing methods vary, reasonable minor variations are expected; however, performance and material requirements specified herein are the minimum standards acceptable. The Owner's Representative retains the sole right to judge the equality of equipment that deviates from the Contract Documents, to reject any substitutions submitted by the Contractor, and to require the specified materials and equipment which conform to the requirements of the Contract Documents be furnished.

C. Equipment and materials that have defects or damage during transportation, installation, or operation is considered as totally damaged. They shall be replaced new. The materials and equipment which have minor damage may be repaired if written approval is given by the Owner. If equipment and materials are approved for repairs, they shall be repaired in a manner acceptable to the Owner at no additional cost to the Owner. The Contractor shall be responsible for all costs associated with the repairs, replacement, including but not limited to, all preparations prior to re-testing, extended warranties, re-commissioning of the equipment, etc.

D. Where no specific make of material or equipment is mentioned, use any product of reputable manufacturer which conforms to requirements of the project, the associated system and other applicable specification sections.

PART 3 - EXECUTION

3.1 PENETRATIONS:

A. Avoid, if possible, the penetration of any waterproof membranes such as roofs, machine room floors, basement slabs and walls, and the like. If such a penetration is necessary, perform it prior to the waterproofing and furnish all sleeves or pitch-pockets required. Advise the Owner's Representative and obtain written permission before penetrating any waterproof membrane, even where such penetration is shown on the Drawings.

1. Any sleeves required shall extend 2" above finished floor

B. If Contractor penetrates any walls or surfaces after they have been waterproofed, he shall restore the waterproof integrity of that surface as directed by the Owner's Representative at his own expense.

C. Pack space between conduits, sleeves, cable trays and seal unused sleeves in non-fire rated walls with non-combustible materials. Refer to specifications for details and requirements.

D. Conduit enters the building through a concrete foundation wall below grade level; a watertight entrance seal shall be used. The seal shall be OZ/Gedney.

E. Make penetrations through floors, walls and any damp-proofed/water-proofed surfaces, damp-proof/waterproof by appropriate means to maintain integrity of system penetrated. Refer to specifications for details and requirements.

F. Seal around penetrations and between conduits, cable trays, sleeves, etc and seal unused sleeves, in fire rated walls with UL listed fireproofing system to maintain fire rating integrity of penetrated membrane. Refer to specifications for details and requirements.

G. The Contractor shall be responsible for the timely placing of sleeves for all piping passing through walls, partitions, beams, floors, and roofs, while the same are under construction.

3.2 EXPANSION/DEFLECTION

A. Equip all cable trays and conduits, including those embedded in concrete, which cross building expansion or control joints, with expansion fittings.

B. Where conduits are subjected to expansion and movement in any directions or to vibration transmitted by equipment or vehicular traffic, install a combination expansion and deflection fittings.

3.3 SUPPORT

A. Provide required supports and hangers for conduit and equipment, so that loading will not exceed allowable loadings of structure. Submittal of a bid shall be deemed a representation that such bid has included allowable loadings and has included the costs associated in furnishing required supports.

B. The design of the supports for conduits, busway and equipment shall be certified and sealed by a Professional Engineer licensed in the State in which the work is to be performed.

C. Where busway, conduits, etc., are routed vertically through shafts, the Contractor shall provide and install all necessary miscellaneous structural members to support the loads imposed by the risers.

D. Where equipment (transformers, busway, conduit racks, etc.) are supported from structural slabs, the Contractor shall provide all miscellaneous structural members to support the load plus a 250 lb. live load.

E. The Contractor shall submit Shop Drawings of the riser support system inside vertical shafts to the Owner's Representative for review, including details of how the riser support structure is to be attached to the building structure

F. Miscellaneous structural support members installed in Electrical Rooms, electric closets, central plants, Mechanical Rooms shall be galvanized steel.

G. Include supporting frames or racks extending from floor slab to ceiling slab for work indicated as being supported from walls where the walls are incapable of supporting the weight. In particular, provide such frames or racks in electric closets.

H. Include supporting frames or racks for equipment, intended for vertical surface mounting, which is required in a freestanding position. Supporting frames or racks shall be of standard angle, standard channel or specialty support system steel members. They shall be rigidly bolted or welded together and adequately braced to form a substantial structure. They shall be firmly secured to the floor slab with expansion anchors designed to support the system and the equipment. Racks shall be of ample size to assure a workmanlike arrangement of all equipment mounted on them and shall not impinge code required work space of other equipment, devices, access panel, junction boxes, pull boxes, etc.

I. Wall mounted equipment may be directly secured to wall by means of steel bolts. Maintain at least 1" air space between equipment and supporting wall. Groups or arrays of equipment may be mounted on adequately sized steel angles, channels, or bars. Prefabricated steel channels providing a high degree of mounting flexibility, such as those manufactured by Kindorf, Glob-Strut and Unistrut, may be used for mounting arrays of equipment.

J. No equipment, including outlet, pull and junction boxes and fittings, shall depend on electric conduits, raceways, or cables for support, except that threaded hub type fittings having a gross volume not in excess of 100 cubic inches may be supported from heavy wall conduit, where the conduit in turn is securely supported from the structure within five inches of the fitting on two opposite sides.

K. Nothing shall rest on, or depend for support on, suspended ceiling media (tiles, lath, plaster, as well as splines, runners, bars and the like in the plane of the ceiling). If suspended ceilings are use to support lighting fixtures, they shall be designed to support the weight of the fixtures. Branch circuit conduit up to 3/4" may be permitted to be supported from ceiling hanger rods if the allowable loading of the rods is not exceeded as agreed by the Owner's Representative.

L. For items, which are shown, as being ceiling mounted at locations where fastening to the building construction element above is not possible, provide suitable auxiliary channel or angle iron bridging, tying to the building structural elements.

3.4 DISSIMILAR METALS

A. Dissimilar metals shall mean those metals, which are incompatible with one another in the presence of moisture. Where dissimilar metals come in contact, paint the joint both

inside and out with appropriate coating so as to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

B. Transitions in raceways, from one metal to a dissimilar metal shall only be made at boxes or other enclosures.

3.5 CUTTING, PATCHING, SLEEVES

A. The work shall be carefully laid out in advance. Where cutting, channeling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support or anchorage of raceway, outlets or other equipment, the work shall be carefully done and where required, fire rating integrity shall be restored. Any damage to the piping, equipment or defaced finish plaster, woodwork, metalwork, etc. shall be repaired by skilled mechanics of the trades involved at no additional cost to the Owner. Refer to architectural specifications for details and requirements.

B. The Contractor shall do no cutting, channeling, chasing or drilling of unfinished masonry, tile, floor slab, etc., unless he first obtains permission from the Owner's Representative. If permission is granted, the Contractor shall perform this work in a manner consistent with the Contract Documents.

C. If holes and/or sleeves are not properly installed and cutting and patching becomes necessary, it shall be done at no additional expense to the Owner. The Contractor shall undertake no cutting or patching without first securing the Owner's Representative's written permission.

D. Where other Trades are required to do cutting and patching, furnish to the Construction Manager necessary information so that openings for this work can be built into the floors and walls in time. Such cooperation is required to keep cutting of walls and floors to a minimum.

E. Should Contractor neglect to perform preliminary work, and should cutting be required in order to install equipment, conduits, etc, the expense of this cutting and restoring of surfaces to their original condition shall be borne by this Contractor.

3.6 PAINTING

A. Equipment furnished under this Section shall have factory-applied finish. If the factory finish is damaged during shipment, storage, installation, etc., it shall be repainted by this Contractor subject to review by the Owner's Representative. Touch-up painting is acceptable only for minor finish damage.

B. Provide a heavy field coat of black asphaltum paint on all steel conduits, cradles, vibration isolating mounts, and the like, that will be encased or partially encased in building construction, set in cement or fill, before items are built into the general construction.

C. Where conduits, mounting channels, outlet, junction, or pull boxes are mounted on a painted surface, or a surface to be painted they shall be painted, by this contractor, to match the surface.

3.7 CLEANING UP

A. Contractor shall take care to avoid accumulation of debris, boxes, crates, etc., resulting from the installation of the work. Contractor shall remove from the premises each day all debris, boxes, etc., and keep the premises clean, subject to the Owner's instructions, which shall be promptly carried out.

B. Contractor shall clean up all luminaires and equipment at the completion of the project.

C. All switchboards, switchgear, busway, panelboards, wireways, transformers, transfer switches, trench ducts, cabinets, enclosures, etc. shall be thoroughly vacuumed clean prior to energizing equipment and at the completion of the project. Equipment shall be opened for observation by the Owner's Representative as required.

3.8 EQUIPMENT PADS AND MOUNTING

A. Provide fully dimensioned pad layouts based on data from manufacturer of electrical equipment. Shop Drawings shall be used for dimensional guidance in sizing pads, anchor bolts, locations, etc.

B. Pads shall be provided for floor-mounted equipment, equipment mounted on legs and/or support stands and they shall conform to the shape of the piece of equipment it serves with a minimum 3 in. margin around the equipment and supports. Pads shall be 4 in. high and made of a minimum 28-day, 3000 psi concrete reinforced with 6"x6", 6/6 gauge welded wire mesh. Top and sides of the pad shall be troweled to smooth finishes, equal to those of the floors, with all corners bullnosed to 3 / 4" radius.

C. Pads shall be dowelled into structural slab with #4 rebars at each corner embedded 3" and grouted with non-shrink grout.

D. Furnish and install galvanized anchor bolts for all equipment placed on concrete equipment pads, inertia blocks, or on concrete slabs. Bolts shall be the size and number recommended by the manufacturer of the equipment and as required for seismic restraint. Anchor bolts shall be anchored to the structural floor slab and shall be located by means of suitable templates. When equipment is placed on vibration isolators, the equipment shall be secured to the isolator and the isolator secured to the floor, pad, or supported as recommended by the vibration isolation manufacturer.

E. Equipment pads for switchboards, switchgear and transformers shall have level mounting channels embedded in the concrete as specified in the applicable sections. Where equipment is mounted on gypsum board partitions, the mounting screws shall pass through the gypsum board and be securely attached to the partition studs or framework.

3.9 EQUIPMENT NOISE AND VIBRATION

A. Equipment and systems, as defined herein, shall be quiet and free of apparent vibration while in operation.

B. Vibration shall not be apparent to the senses in occupied areas of the building. Both the balancing of rotating machinery and the installation of vibration isolators are required.

C. Any additional precautions deemed necessary to provide a quiet installation shall be done as part of the Work of this Section, subject to review by the Owner's Representative and without additional cost to the Owner. After the systems are in operation, it shall be the responsibility of the Contractor to make any changes to equipment or Work.

3.10 FINAL ACCEPTANCE TESTS

A. The entire electrical installation shall be pre-tested, inspected, thoroughly cleaned, and damaged finishes touched up after final completion prior to final acceptance testing being performed. Not less than 30 days prior to the final acceptance testing, furnish the pre-test results and a test plan to the Owner for review, outlining all aspects of the testing, including tests to be performed and the expected results.

B. Provide complete documentation of all component and system tests prior to Owner acceptance and turnover of components or systems. In addition, the Owner reserves the right to review all test objectives, test plans and test cases, and witness all preoperational tests. Provide the Owner with a comprehensive schedule detailing the preparation of testing documentation and the conduct of all component or system tests.

C. Perform the following field test in the presence of the Owner's Representative to demonstrate the reliability of the electrical installation. Give the Owner's Representative a minimum two-week advance notice of such tests.

D. Operate all electrical systems and equipment for a period of 24 hours, unless in the opinion of the Owner's Representative, a different test period is required, to prove the operation and performance of a system and its equipment.

E. Should the foregoing test reveal any defects, promptly correct such defects and re-run the tests until the entire installation conforms to the requirements of these Specifications and the Drawings.

F. Tests requiring certified reports and those requiring factory or field inspection shall be conducted and reported to the Owner's Representative in conformance with standards specified in the applicable sections.

G. Thermo-graphic Inspection

1. In addition to the tests outlined above, after completion of the electrical system and prior to occupancy, the following equipment and devices, as a minimum, shall be thermo-graphically inspected.

    a. Feeder splices and connections.
    b. Panelboards.
    c. Emergency power system connections.

d. Other equipment as shown on the Drawings or indicated in the specification's.

2. The inspection shall be made by an independent inspection company. The inspection shall be made with all equipment, motors, lighting fixtures, and miscellaneous loads operating and with equipment covers removed.
3. Inspection reports complete with color photographs of the infrared scan and control photographs indicating the ambient temperature and any hot spots of each item inspected shall be submitted to the Owner's Representative for review. Any equipment, connections or devices indicated to be operating improperly performing equipment shall be replaced or repaired by the Contractor at no cost to the Owner.

H. The date for the final performance acceptance testing shall comply with the Project construction schedule and shall be sufficiently in advance of the Contract completion date to permit the execution of the testing by the Contractor prior to occupancy and the close-out of the Contract. Any adjustments and/or alterations which the final acceptance tests indicate as necessary for the proper and satisfactory functioning of all equipment and systems shall be completed prior to the close-out of the Contract. Re-tests shall not relieve the Contractor of completion date responsibility.

I. The Contractor shall provide a detailed schedule of completion indicating when each system is to be completed and outlining when tests will be performed. Completion schedule shall be submitted to the Owner for review at the time requested by the Construction Manager after the notice to proceed has been given by the Owner. This schedule shall be updated periodically by the Contractor as the Project progresses. Each update shall be submitted to the Owner for review.

J. Contractors' tests shall be scheduled and documented in accordance with the commissioning requirements. Refer to Section 019100, Commissioning, for further details.

3.11 DEMONSTRATION AND OPERATION INSTRUCTIONS

A. After completion of all testing, and prior to placing equipment or systems in operation, demonstrate the features and operation of the equipment or systems to the Owner's operational and maintenance personnel so that they are familiarized with the equipment and systems, in particularly the following equipment and systems:

1. Switchboards and panelboards.
2. Transformers.
3. Switchgear.
4. Power monitoring system
5. Emergency power system
6. Lighting Control system
7. Fire alarm and smoke detection systems.
8. Automatic transfer switches
9. Other equipment and control systems shown on the Drawings.

B. Provide the necessary accessories, test equipment, and personnel, for each demonstration.

C. Complete all arrangements for the demonstrations through the Owner's Representative.

D. Upon the completion of each demonstration or instructional session, obtain "sign-off" from the Owner. The "sign-off" shall state that the demonstration or instructions for use were provided, that they were complete and were given to the designated personnel.

E. The Contractor shall provide the services of a factory trained specialist to supervise the commissioning, startup, and operation of all equipment specified herein and to instruct the Owner's operators during an operating instruction period at or near the Project site. The operating instruction period shall be defined as straight time working hours and shall not include nights, weekends, or travel time to and/or from the Project. See individual sections of these specifications for additional instructions by manufacturer-trained specialists.

F. The Owner's Representative shall be notified in writing at least two (2) weeks before each operating instruction period begins. The Contractor shall commence no instruction period until the Owner's Representative has issued his written acceptance of the starting time.

3.12 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall provide operating instructions and maintenance data books for all equipment and materials specified in this Division.

B. Submit six (6) copies of operation and maintenance manuals for review at least ten (10) weeks before Final Review of the Project. Assemble all data in a completely indexed volume or volumes in three-ring binders and identify the size, model, and features indicated for each item. The binders shall have the Project Name and Logo printed on the outside of the binders. These manuals shall be submitted and subjected to the same review process as detailed for shop drawings and samples as provided in Article 1.18 but shall be returned as "REVIEWED." Submit four (4) copies of the "REVIEWED" operation and maintenance books to the Construction Manager upon Project completion.

C. Operation and Maintenance manuals shall include complete cleaning, and servicing data compiled in clearly and easily understandable form. Data shall show serial numbers and model numbers of each piece or equipment, complete lists of replacement parts (including part numbers), motor ratings, and actual loads.

D. Include the following information where applicable:

1. Identifying name and mark number.
2. Locations of major equipment (where several similar items are used, provide a list).
3. Complete nameplate data.
4. "Reviewed" submittals as returned to this Contractor.
5. Parts lists.

6. Performance curves and data.
7. Wiring diagrams.
8. Lubrication charts.
9. Manufacturers' recommended operation and maintenance instructions with all non-applicable information deleted.
10. List of spare parts recommended for normal service requirements.
11. Assembly and disassembly instructions with exploded view Drawings where available.
12. Trouble shooting diagnostic instructions where available.

3.13 FINAL REVIEW

A. At a time designated, the entire installation shall be reviewed for compliance with the Contract Drawings and Specifications. The Contractor shall be available at all times during this Review.

B. The Contractor shall demonstrate prior to the Final Review that all systems and all equipment have been properly adjusted and are in compliance with the requirements of the Contract Documents. After the demonstration tests are completed satisfactorily, but prior to the Final Review field visit, the Contractor shall submit to the Owner's Representative a written certification that:

1. attests to Contract Document compliance for this Project, and
2. certifies that the equipment and materials installed in this Project contain no asbestos or PCB.

C. Certificates and Documents required herein shall be in order and presented to the Owner's Representative at least two (2) weeks prior to the Final Review.

D. After the Final Review, any changes or corrections noted as necessary for the Work to comply with these Specifications and the Drawings shall be accomplished without delay in order to secure final acceptance of the Work.

End of Section

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Section 26 05 13
MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes cables and related cable splices, terminations, and accessories for medium-voltage (2001 to 35,000 V) electrical distribution systems.

1.3 DEFINITIONS

A. Jacket: A continuous nonmetallic outer covering for conductors or cables.

B. NETA ATS: Acceptance Testing Specification.

C. Sheath: A continuous metallic covering for conductors or cables.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Indicate location of each cable, splice, and termination.

B. Qualification Data: For Installer and testing agency.

C. Design Data: Cable pulling calculations, including conduit size and fill percentage, pulling tensions, cable sidewall pressure, jam probability, voltage drop, and ground wire sizing for each cable.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
2. An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
3. Comply with IEEE C2 and NFPA 70.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.7 FIELD CONDITIONS

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager, Owner, and Engineer no fewer than seven days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2 and NFPA 70.

C. Source Limitations: Obtain cables from single source from single manufacturer.

2.2 CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Okonite Company (The).

2. General Cable; General Cable Corporation.
3. Kerite Co. (The).
4. Southwire Company.

B. Cable Type: Type MV 105.

C. Conductor Insulation: **Ethylene-propylene rubber**.

1. Voltage Rating: **15** kV.
2. Insulation Thickness: **133** percent insulation level.

D. Conductor: Copper.

E. Comply with UL 1072, AEIC CS8, and ICEA S-94-649.

F. Conductor Stranding: Concentric lay, Class B.

G. Lead Content: Less than 300 parts per million.

H. Shielding: Copper tape, helically applied over semiconducting insulation shield.

I. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.

J. Cable Jacket: Sunlight-resistant PVC.

2.3 CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. Cooper Power Systems, an Eaton business.
3. Raychem; a brand of nVent.
4. Thomas & Betts Corporation; A Member of the ABB Group.

B. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.

C. Copper-Conductor Connectors: Aluminum barrel crimped connectors.

2.4 SOLID TERMINATIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Power Systems, an Eaton business.
2. G&W Electric Company.
3. Raychem; a brand of nVent.
4. Thomas & Betts Corporation; A Member of the ABB Group.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.
2. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
3. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
4. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
5. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape; cold-shrink-rubber sleeve; or heat-shrink, plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
6. Class 3 Terminations: Kit with stress cone and compression-type connector.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. Cooper Power Systems, an Eaton business.
3. G&W Electric Company.
4. Raychem; a brand of nVent.
5. Elastimold/Thomas & Betts Corporation; A Member of the ABB Group.

C. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

D. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

F. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

G. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 SPLICE KITS

A. Description: For connecting medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.

B. Standard: Comply with IEEE 404.

C. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

1. Combination tape and cold-shrink-rubber sleeve kit with rejacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
2. Premolded, EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.
3. Separable multiway splice system with all components for the required splice configuration.

2.7 MEDIUM-VOLTAGE TAPES

A. Description: Electrical grade, insulating tape rated for medium voltage application.

B. Ethylene/propylene rubber-based, 30-mil (0.76-mm) splicing tape, rated for 130 deg C operation. Minimum 3/4 inch (20 mm) wide.

C. Silicone rubber-based, 12-mil (0.30-mm) self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inches (38 mm) wide.

D. Insulating-putty, 125-mil (3.175-mm) elastic filler tape. Minimum 1-1/2 inches (38 mm) wide.

2.8 ARC-PROOFING MATERIALS

A. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, and compatible with cable jacket. Plymouth Brand Ply-Arc 30 or approved equal.

B. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch (25 mm) wide. 3M Scotch Brand 27 or approved Equal

2.9 FAULT INDICATORS

A. Indicators: Manually reset fault indicator, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.10 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-94-649 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches (1200 to 1800 mm) on the pull rope.

1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

D. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

E. Install "buried-cable" warning tape 12 inches (305 mm) above cables.

F. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.

G. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

H. Install cable splices at pull points and elsewhere as indicated; use standard kits. Use dead-front separable watertight connectors in manholes and other locations subject to water infiltration.

I. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.

J. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
3. Standoff Insulator: At each terminal junction, with one on each terminal.

K. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with two layers of 1-inch- (25-mm-) wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

L. Seal around cables passing through fire-rated elements according to Section 078413 "Penetration Firestopping."

M. Install fault indicators on each phase where indicated.

N. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

O. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.

P. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer's recommended maximum test voltage.
4. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
5. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.

D. Medium-voltage cables will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

End of Section

Section 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Copper building wire.
2. Metal-clad cable, Type MC.
3. 300V Control Wire and Cable
4. Mineral-insulated cable, Type MI.
5. Connectors and splices.

B. Related Requirements:

1.3 DEFINITIONS

A. RoHS: Restriction of Hazardous Substances.

B. VFC: Variable-frequency controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Belden Inc.
2. Cerro Wire LLC.
3. Encore Wire Corporation.
4. Okonite Company (The).
5. Southwire Company.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Material: Copper with 98% minimum conductivity using insulation types THHN/THWN, XHHW or THW per NFPA 70 and UL, unless otherwise noted.

E. Individual Conductors:

1. Single conductor insulated wire.
2. Solid or stranded for size 10 AWG and smaller, and stranded for size 8 AWG and larger.
3. Branch circuit neutrals shall have marks on each conductor to identify which phase the branch circuit associated with the neutral is connected to.

F. Shield:

1. Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires, and sunlight- and oil-resistant outer PVC jacket.

2.2 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems; a part of Atkore International.
2. Belden Inc.
3. General Cable.
4. Encore Wire Corporation.
5. Okonite Company (The).
6. Southwire Company.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. RoHS compliant.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits:

1. Single circuit.

E. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

F. Ground Conductor: Bare.

G. Conductor Insulation:

1. Type XHHW-2 or THHN/THWN

H. Armor: Interlocked aluminum armor helically formed around the conductor assembly.

2.3 MINERAL-INSULATED CABLE, TYPE MI

A. Description: Solid copper conductors encased in compressed metal oxide with an outer metallic sheath, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. KME America, Inc.
2. Pentair.
3. Watlow Electric Manufacturing Company.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. UL 2196 for fire resistance.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper.

E. Insulation: Compressed magnesium oxide.

F. Sheath: Copper.

2.4 300 VOLT CONTROL WIRE AND CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Alpha.
2. Belden.

B. MULTI-CONDUCTOR CONTROL CABLE
1. Description: Multi-conductor insulated cable with color-coded PVC insulation over each conductor and an overall PVC jacket.
2. Conductor: Copper, stranded.
3. Insulation Voltage Rating: 300V.
4. Temperature Rating: -20 degrees C to +80 degrees C.
5. Agency Certification: UL recognized, passes VW-1 flame test.

2.5 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M Electrical Products.
2. ABB (Electrification Products Division).
3. Appleton - O-Z/Gedney; Emerson Electric Co., Automation Solutions.
4. Atkore International (AFC Cable Systems).
5. Hubbell Incorporated, Power Systems.
6. NSi Industries LLC.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper.
2. Type: Two hole with long barrels.
3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders:

1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits:

1. Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN or XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN or XHHW-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN or XHHW-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN/THWN or XHHW-2, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN or XHHW, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN or XHHW-2, single conductors in raceway or Metal-clad cable, Type MC.

H. Branch Circuits for final connections to luminaires and motors: Metal-clad cable, Type MC

I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

J. Branch Circuits Installed below Raised Flooring: Type THHN/THWN or XHHW-2, single conductors in raceway or Metal-clad cable, Type MC.

K. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.

L. VFC Output Circuits: Type TC-ER cable with braided shield.

3.3 INSTALLATION, GENERAL

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

D. Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" for connecting, terminating, and identifying wires and cables.

3.5 IDENTIFICATION

A. Color Coding: All power conductors identified as to phase and voltage by means of color impregnated insulation, as follows:

Voltage	ØA	ØB	ØC	Neutral	Ground
120/208V	Black	Red	Blue	White	Green
277/480V	Brown	Orange	Yellow	Gray	Green

For wire sizes No. 8 AWG and larger, colored tape per 260553, minimum 2 inches wide, may be used at all accessible locations in lieu of integrally colored insulation.

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Administrant for Tests and Inspections:

1. Engage qualified testing agency to administer and perform tests and inspections.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.

2. Perform each of the following visual and electrical tests:

a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
b. Test bolted connections for high resistance using one of the following:

1) A low-resistance ohmmeter.
2) Calibrated torque wrench.

3) Thermographic survey.

c. Inspect compression-applied connectors for correct cable match and indentation.
d. Inspect for correct identification.
e. Inspect cable jacket and condition.
f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
g. Continuity test on each conductor and cable.
h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

C. Cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

End of Section

Section 26 05 23

CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL with a field supervisor certified by BICSI as an RCDD.

1.2 PRODUCTS

A. Pathways:

1. Open Cabling: Support brackets with cable tie slots, lacing bars, spools, J-hooks, and D-rings.

2. Conduit and boxes.

B. RS-232 Cable: Plenum rated, Type CMP, two pair, No. 22 AWG, stranded copper; each pair 100 percent shielded, copper drain wire.

C. RS-485 Cable: Plenum rated, Type CMP, two twisted pair, No. 22 AWG, stranded copper, unshielded.

D. Low-Voltage Control Cable:

1. Paired Cable: No. 16 AWG, plenum-rated, Type CMP, twisted pair.
2. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway.
3. Class 2 Control Circuits: Stranded copper, power-limited cable, concealed in building finishes.
4. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF.

E. Identification products.

1.3 INSTALLATION

A. Wiring Method: Concealed cable.

B. Remove abandoned conductors and cables.

1.4 FIELD QUALITY CONTROL

A. Testing: By Contractor-engaged agency.

End of Section

Section 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

    a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:

        1) Test wells.
        2) Ground rods.
        3) Ground rings.
        4) Grounding arrangements and connections for separately derived systems.

    b. Instructions for periodic testing and inspection of grounding features at **test wells** based on **NETA MTS.**.

        1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
        2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    1. Thomas and Betts/ABB
    2. Burndy; Part of Hubbell Electrical Systems.
    3. Dossert; AFL Telecommunications LLC.
    4. ERICO International Corporation.
    5. Fushi Copperweld Inc.
    6. Galvan Industries, Inc.; Electrical Products Division, LLC.
    7. Harger Lightning and Grounding.
    8. ILSCO.

9. O-Z/Gedney; A Brand of the EGS Electrical Group.
10. Robbins Lightning, Inc.

2.3 CONDUCTORS

A. Insulated Conductors: **Copper** wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Grounding electrode conductors shall be a minimum of #4/0 AWG unless otherwise indicated, and shall be continuous without joints or splices.

C. Equipment grounding conductors shall have green insulation. Where continuous color-coded conductors are not commercially available, provide a minimum 4" long color band with green, non-aging, plastic tape.

D. Grounding Electrode Conductors: Stranded cable.

E. Underground Conductors: #4/0 AWG bare, tinned, stranded, unless otherwise indicated.

F. Bare Copper Conductors:

1. Solid Conductors: ASTM B3.
2. Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.4 GROUND BARS

A. Grounding Bus bar: Predrilled rectangular bars of annealed copper, Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

B. Provide 4" H. x 1/4" thick copper bus bar 24” long or length as noted on drawings. Mount on walls in locations shown and on insulating standoffs.

C. Provide cast copper alloy body lugs for connecting grounding system cables. Attach lugs to bus with appropriate size cadmium bronze bolt, flat washer and Belleville washer. All connections shall be torqued. Provide 6 spare lugs and lug spaces unless otherwise noted.

D. Provide 2”x 1/4” copper ground bus around perimeter of MV switchgear room and Hubbell grounding ball studs cat C6002102 or approved equal.

2.5 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless **compression**-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

G. Conduit Hubs: Mechanical type, terminal with threaded hub.

H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

I. Lay-in Lug Connector: Mechanical type, **copper rated for direct burial** terminal with set screw.

J. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

K. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

L. Straps: Solid copper, **cast-bronze clamp**. Rated for 600 A.

M. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal **two**-piece clamp.

N. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

O. Water Pipe Clamps:

1. Mechanical type, two pieces with **zinc-plated** bolts.

    a. Material: **Tin-plated aluminum**.
    b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and **copper ground connector rated for direct burial**.

2.6 GROUNDING ELECTRODES

A. Ground Rods: **Copper-clad steel**; **3/4 inch by 10 feet (19 mm by 3 m)**.

B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with **nonhazardous electrolytic chemical salts**.

1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
2. Backfill Material: Electrode manufacturer's recommended material.

C. Ground Plates: 1/4 inch (6 mm) thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for **No. 8** AWG and smaller, and stranded conductors for **No. 6** AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, **No. 2/0** AWG minimum.

1. Bury at least 30 inches (750 mm) below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.

C. Grounding Conductors: Green-colored insulation with continuous yellow stripe.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.

8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

G. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

2. Use exothermic welds for all below-grade connections.
3. For grounding electrode system, install at least **three** rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.

1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install **tinned** bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each **indicated item**, extending around the perimeter of **area or item indicated**.

1. Install tinned-copper conductor not less than **No. 2/0** AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than **24 inches (600 mm)** from building's foundation.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of **20 feet (6 m)** of bare copper conductor not smaller than **No. 4** AWG.

1. If concrete foundation is less than **20 feet (6 m)** long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

K. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections **with the assistance of a factory-authorized service representative**.

E. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal**, at ground test wells**. Make tests at ground rods before any conductors are connected.

a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

F. Grounding system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: **10** ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: **5** ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: **3** ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: **1** ohm(s).

I. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

End of Section

Section 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Aluminum slotted support systems.
3. Conduit and cable support devices.
4. Support for conductors in vertical conduit.
5. Structural steel for fabricated supports and restraints.
6. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
7. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. Section 03 3000 – “Cast-in-Place Concrete” for concrete equipment pads.
2. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Sockets.
e. Eye nuts.
f. Fasteners.
g. Anchors.
h. Saddles.

i. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.
2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Ductwork, piping, fittings, and supports.
3. Structural members to which hangers and supports will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

a. Luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Projectors.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB (Electrification Products Division).
b. Atkore International (Allied Tube & Conduit).
c. Atkore International (Unistrut).
d. Eaton (B-line).
e. nVent (CADDY).

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Galvanized steel.
4. Channel Width: Selected for applicable load criteria.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Hilti, Inc.
2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
3) MKT Fastening, LLC.
4) Simpson Strong-Tie Co., Inc.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      1) Eaton (B-line).
      2) Hilti, Inc.
      3) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      4) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325 (Grade A325M).
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA 101
3. NECA 105.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
9. Provide vibration isolation between conduit support system and structure for all conduits connected to transformers 1,000 kVA and larger, and all rotating or vibrating equipment.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
4. Provide vibration isolation (Type BR or Equal) between all transformers and concrete bases.

End of Section

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Section 26 05 33

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Surface raceways.
5. Boxes, enclosures, and cabinets.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.
2. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
3. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.

1.3 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Sustainable Design Submittals:

1. Product Data: For solvents and adhesives, indicating VOC content.

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AFC Cable Systems; a part of Atkore International.
b. Allied Tube & Conduit; a part of Atkore International.
c. FSR Inc.
d. Southwire Company.
e. Thomas & Betts Corporation; A Member of the ABB Group.

2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. EMT: Comply with ANSI C80.3 and UL 797.
6. FMC: Comply with UL 1; zinc-coated steel.
7. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:
1. Manufacturers: Obtain fittings and accessories from same manufacturer as conduits.
2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.

5. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
6. Fittings for EMT:

    a. Material: Steel.
    b. Type: compression.

7. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
8. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. AFC Cable Systems; a part of Atkore International.
    b. Cantex Inc.
    c. Hubbell Incorporated (Commercial and Industrial Group - RACO).
    d. Thomas & Betts Corporation; A Member of the ABB Group.

2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
4. LFNC: Comply with UL 1660.

B. Nonmetallic Fittings:
1. Manufacturers: Obtain fittings and accessories from same manufacturer as conduits.
2. Fittings, General: Listed and labeled for type of conduit, location, and use.
3. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

    a. Fittings for LFNC: Comply with UL 514B.

4. Solvents and Adhesives: As recommended by conduit manufacturer.
5. Verify adhesive complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and

Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB (Electrification Products Division).
2. Eaton (B-line).
3. Schneider Electric USA (Square D).

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. MonoSystems, Inc.
b. Wiremold; Legrand North America, LLC.
c. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB (Electrification Products Division).
2. Eaton (Crouse-Hinds).
3. Hubbell Incorporated.
4. Raco Taymac Bell; Hubbell Incorporated, Commercial and Industrial.
5. Wiremold; Legrand North America, LLC.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Metal Floor Boxes:

1. Material: Cast metal or sheet metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.

F. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb (32 kg).

1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).

K. Gangable boxes are prohibited.

L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

M. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground and Underslab Conduit: Refer to section 260543 “Underground Ducts and Raceways for Electrical Systems”.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Utility tunnels.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT or MC cable.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4X stainless steel in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

H. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Complete raceway installation before starting conductor installation.

G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.

I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches (300 mm) of enclosures to which attached.

L. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 1 inch (25 mm) of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from ENT to GRC before rising above floor.

M. Stub-Ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

P. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

Q. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

R. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

S. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

T. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

U. Surface Raceways:

1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

V. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

W. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

X. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

Y. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
    d. Attics: 135 deg F (75 deg C) temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of

straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.

4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

Z. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 36 inches (915 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations.

AA. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

BB. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

CC. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

DD. Locate boxes so that cover or plate will not span different building finishes.

EE. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

FF. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

GG. Set metal floor boxes level and flush with finished floor surface.

HH. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install 0sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

End of Section

Section 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
2. Rigid nonmetallic duct.
3. Duct accessories.
4. Precast concrete handholes.
5. Polymer concrete handholes and boxes with polymer concrete cover.
6. Precast manholes.

B. Utility structure accessories

1.3 DEFINITIONS

A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

C. Duct Bank:

1. Two or more ducts installed in parallel, with or without additional casing materials.
2. Multiple duct banks.

D. GRC: Galvanized rigid (steel) conduit.

E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include duct-bank materials, including spacers and miscellaneous components.
2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes, and other utility structures.
4. Include underground-line warning tape.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:

a. Include plans, elevations, sections, details, attachments to other work, and accessories.
b. Include duct entry provisions, including locations and duct sizes.
c. Include reinforcement details.
d. Include frame and cover design and manhole chimneys.
e. Include ladder details.
f. Include grounding details.
g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
h. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For duct and duct bank. Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

C. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C858.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 MAINTENANCE MATERIALS SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.

1.8 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Architect, Construction Manager, and Owner no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

A. GRC: Comply with ANSI C80.1 and UL 6.

B. Coated Steel Conduit: PVC-coated GRC.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AFC Cable Systems; a part of Atkore International.

b. Allied Tube & Conduit; a part of Atkore International.
c. FSR Inc.
d. Southwire Company.
e. Thomas & Betts Corporation; A Member of the ABB Group.

D. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-80-PVC and Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ARNCO Corp.
2. Cantex Inc.
3. Condux International, Inc.
4. Opti-Com Manufacturing Network, Inc (OMNI).
5. Spiraduct/AFC Cable Systems, Inc.

C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

1. VOC Content:**510** g/L or less for PVC conduit and fittings.

2.3 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Atkore International (Allied Tube & Conduit).
b. Cantex Inc.
c. Carlon; a brand of Thomas & Betts Corporation.
d. IPEX USA LLC.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

C. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 75 mm) in size, manufactured from 6000-psi (41-MPa) concrete.

1. Color: Red dye added to concrete during batching.
2. Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

2.4 PRECAST CONCRETE HANDHOLES AND BOXES

A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Christy Concrete Products.
2. Oldcastle Precast, Inc.
3. Riverton Concrete Products.
4. Utility Concrete Products, LLC.
5. Utility Vault Co.

C. Comply with ASTM C858 for design and manufacturing processes.

D. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

E. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

F. Cover Legend: Molded lettering, "ELECTRIC."

G. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.

H. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

1. Extension shall provide increased depth of 12 inches (300 mm).
2. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

I. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

J. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.5 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Armorcast
2. Hubbell (Quazite)
3. Oldcastle Precast, Inc.

C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

D. Color: Gray.

E. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.

F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

H. Cover Legend: Molded lettering, "ELECTRIC."

I. Direct-Buried Wiring Entrance Provisions (where required): Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

K. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.6 PRECAST MANHOLES

A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Christy Concrete Products.
2. Oldcastle Precast, Inc.
3. Riverton Concrete Products.

4. Utility Concrete Products, LLC.
5. Utility Vault Co.

C. Comply with ASTM C858.

D. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

E. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.

1. Center window location.
2. Knockout panels shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
4. Knockout panel shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
5. Knockout panels shall be 1-1/2 to 2 inches (38 to 50 mm) thick.

F. Ground Rod Sleeve: Provide a 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the duct entering the structure.

G. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.7 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C1037.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

3.2 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Primary Service Feeders: 5-inch Type EPC-40-PVC RNC, concrete-encased.

B. Duct for Electrical Secondary Service-Entrance Feeders: 5-inch Type EPC-40-PVC RNC, concrete-encased.

C. Duct for Electrical Feeders 600 V and Less: Type EPC-80-PVC RNC, direct-buried unless otherwise indicated.

D. Duct for Electrical Branch Circuits: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

E. Underground Ducts Crossing Paved Paths, Walks, Driveways, and Roadways: Type EPC-40 PVC RNC, encased in reinforced concrete.

F. Stub-ups: Concrete-encased GRC.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-10 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Polymer Concrete structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.
5. Units in landscape: Polymer Concrete
6. Cover design load shall not exceed the design load of the handhole or box.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restoration: Replace area immediately after backfilling is completed or after construction vehicle traffic in immediate area is complete.

C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."

E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 017300 "Execution."

3.5 DUCT AND DUCT-BANK INSTALLATION

A. Install duct, spacers, and accessories into the duct-bank. Duct installation requirements in this Section also apply to duct bank.

B. Install duct according to NEMA TCB 2.

C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.

D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1200 mm), both horizontally and vertically, at other locations unless otherwise indicated.

1. Duct shall have maximum of three 90 degree bends or the total of all bends shall be no more 360 degrees between pull points.

E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.

F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) duct, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell, without reducing duct slope and without forming a trap in the line.
2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install

an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch (19 mm).

3. Grout end bells into structure walls from both sides to provide watertight entrances.

H. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches (150 mm) o.c. for 4-inch (100-mm) duct, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to terminator spacing 10 feet (3 m) from the terminator, without reducing duct line slope and without forming a trap in the line.
2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than 3/4 inch (19 mm).

I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet (3 m) outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

K. Pulling Cord: Install 200-lbf- (1000-N-) test nylon cord in empty ducts.

L. Concrete-Encased Ducts and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.
2. Width: Excavate trench 3 inches (75 mm) wider than duct on each side, or as indicated in Civil Engineering drawings.
3. Depth: Install so top of duct envelope is at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles unless otherwise indicated on drawings.
4. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
5. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 feet (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
   a. Minimum 4” concrete base poured and cured for minimum of 24 hours prior to setting base spacers.

6. Minimum Space between Duct: 3 inches (75 mm) between edge of duct and exterior envelope wall, 3 inches (75 mm) between ducts for like services, and 12 inches (300 mm) between power and communications ducts, or as indicated on drawings.
7. Elbows: Use manufactured PVC coated GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.

    a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
    b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 4 inches (100 mm)abovefinished floor and minimum 3 inches (75 mm)from conduit side to edge of slab. Provide conduit seals.

    c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of wall. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 4 inches (100 mm)abovefinished floor and no less than 3 inches (75 mm)from conduit side to edge of slab. Provide conduit seals.

8. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
9. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
10. Concrete Cover: Install a minimum of 3 inches (75 mm) of concrete cover between edge of duct to exterior envelope wall, 3 inches (75 mm) between duct of like services, and 12 inches (300 mm) between power and communications ducts.
11. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

    a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (15-mm) reinforcing-rod dowels extending a minimum of 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.

12. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to

flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

M. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
2. Width: Excavate trench 3 inches (75 mm) wider than duct on each side.
3. Depth: Install top of duct at least 36 inches (900 mm) below finished grade unless otherwise indicated on drawings.
4. Set elevation of bottom of duct bank below frost line.
5. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
7. Install duct with a minimum of 3 inches (75 mm) between ducts for like services and 12 inches (300 mm) between power and communications duct or as indicated on drawings.
8. Install manufactured PVC coated GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.

    a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
    b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 4 inches (100 mm)abovefinished floor and minimum 3 inches (75 mm)from conduit side to edge of slab.

    c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of wall. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 4 inches (100 mm)abovefinished floor and no less than 3 inches (75 mm)from conduit side to edge of slab.

9. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches (100 mm) over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete

backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.

a. Place minimum 3 inches (75 mm) of sand as a bed for duct. Place sand to a minimum of 6 inches (150 mm) above top level of direct buried duct.
b. Place minimum 6 inches (150 mm) of engineered fill above concrete encasement of duct.

N. Underground-Line Warning Tape: Bury conducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 24 inches (600 mm) above all concrete-encased duct and direct buried duct banks and approximately 12 inches (300 mm) below grade. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches (375 mm) below finished grade, or as required per details on drawings.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
3. Install handholes with bottom below frost line.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

E. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

F. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

G. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

H. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (97 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.

D. Install handholes and boxes with bottom below frost line.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

3.8 GROUNDING

A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-(300-mm-) long mandrel equal to duct size minus 1/4 inch (6 mm). If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump.

1. Sweep floor, removing dirt and debris.
2. Remove foreign material.

End of Section

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Section 26 05 44

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Round sleeves.
2. Rectangular sleeves.
3. Sleeve seal systems.
4. Grout.
5. Pourable sealants.
6. Foam sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 ROUND SLEEVES

A. Wall Sleeves, Steel:

1. Description: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral waterstop.

B. Wall Sleeves, Cast Iron:

1. Description: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.

C. Sheet Metal Sleeves, Galvanized Steel, Round:

1. Description: Galvanized-steel sheet; thickness not less than 0.0239-inch (0.6-mm); round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

2.2 RECTANGULAR SLEEVES

A. Sheet Metal Sleeves, Galvanized Steel, Rectangular:

1. Description:

a. Material: Galvanized sheet steel.
b. Minimum Metal Thickness:

1) For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness must be 0.052 inch (1.3 mm).
2) For sleeve cross-section rectangle perimeter not less than 50 inches (1270 mm) or with one or more sides larger than 16 inches (400 mm), thickness must be 0.138 inch (3.5 mm).

2.3 SLEEVE SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable or between raceway and cable.

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.5 FOAM SEALANTS

A. Description: Multicomponent, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam. Foam expansion must not damage cables or crack penetrated structure.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Sleeves for Conduits Penetrating Above-Grade, Non-Fire-Rated, Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

   a. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall or floor so no voids remain. Tool exposed surfaces smooth; protect material while curing.
   b. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless sleeve seal system is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.

C. Sleeves for Conduits Penetrating Non-Fire-Rated Wall Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for wall assemblies.

D. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

E. Aboveground, Exterior-Wall Penetrations: Seal penetrations using cast-iron pipe sleeves and mechanical sleeve seal systems. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

F. Underground, Exterior-Wall and Floor Penetrations:

1. Install cast-iron pipe sleeves with integral waterstops. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve seal system. Install sleeve during construction of floor or wall.

3.2 INSTALLATION OF RECTANGULAR SLEEVES AND SLEEVE SEALS

A. Install sleeves in existing walls without compromising structural integrity of walls. Do not cut structural elements without reinforcing the wall to maintain the designed weight bearing and wall stiffness.

B. Install conduits and cable with no crossings within the sleeve.

C. Fill opening around conduits and cables with expanding foam without leaving voids.

D. Provide metal sheet covering at both wall surfaces and finish to match surrounding surfaces. Metal sheet must be same material as sleeve.

3.3 INSTALLATION OF SLEEVE SEAL SYSTEMS

A. Install sleeve seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

End of Section

SECTION 260553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Equipment identification nameplates.
2. Identification for conductors, cables AC and MC cables
3. Identification for raceways.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Receptacle Identification Labels
8. Miscellaneous identification products.

1.3 REFERENCES

A. American National Standards Institute (ANSI):
1. ANSI A13.1 "Scheme for Identification of Piping Systems"

B. Occupational Safety and Health Administration (OSHA). 29 CFR - Labor Chapter XVII Part 1910-145 "Occupational and Safety Health Standards" 1992.

1.4 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.5 QUALITY ASSURANCE

A. Comply with ANSI A13.1and IEEE C2..

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.6 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT NAMEPLATES

A. Materials:
1. Engraved plastic laminate - three-layer laminated plastic with punched or drilled holes for screw mounting
2. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed
3. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process.
4. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Overlay shall provide a weatherproof and UV-resistant seal for label.
5. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm)

B. Dimension
1. Nameplate minimum of 1 3/4" high by 5" wide.
2. Lettering height for panel or equipment identifier @ 1/4".
3. Lettering height for remaining lines @ 1/8" high with 1/8" spacing between lines.
4. Normal System: White letters on black background.
5. Emergency System: White letters on orange background.
6. Comply with ANSI 13.1.

C. Panelboard Nameplates
1. Provide engraved plastic nameplate for each new panelboard with the following information:

Line 1: Panelboard Name

Line 2: Source from which panel is fed (e.g.Fed From SWBD 4N2A)

Line 3: Transfer switch from which panel is fed (if applicable)

Line 4: Amps, voltage, phase and wire

D. Disconnects, Starters, Combination Starters and Other Devices
1. Provide phenolic nameplate for each device with the following information:

Line 1: Load served

Line 2: Panelboard and circuit number from which device is fed

Line 3: Fuse size or breaker size as applicable

2.2 CONDUCTOR, CABLE AND AC AND MC CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each conductor and cable size.

B. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Snap-Around Labels: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of conductor or cable it identifies and to stay in place by gripping action.

E. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.

2.3 RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1, for minimum lettering size and for minimum length of color field for each raceway size.

B. Color for Raceway Carrying Circuits More than 600 V:
1. Black letters on an orange field.
2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.

C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers diagonally over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stop stripes at legends.

2.4 FLOOR MARKING TAPE

A. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.5 UNDERGROUND-LINE WARNING TAPE

A. Tape:
1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:
1. Comply with ANSI Z535.1 through ANSI Z535.5.

C. Non-Conducting Protective Tapes
1. Pigmented polyolefin, bright-colored, continuous-printed with the inscription noted above compounded for direct-burial service.
2. Thickness: 4 mils (0.1 mm).

D. Protective Tapes Suitable for Conductive or Inductive Tracing.
1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed with the inscription indicated above**,** compounded for direct-burial service.
2. Overall Thickness: 5 mils (0.125 mm).
3. Foil Core Thickness: 0.35 mil (0.00889 mm).

2.6 POSTED DRAWINGS

A. Electrical One-line or Risers: Print electrical one-line/riser diagrams on 20 lb. bond paper. (Blue print paper is not acceptable). Reduce drawings to approximately 1/2 size using Xerox reduction process. Contact engineer to obtain updated original plans for printing.

B. Mounting Frames: Extruded aluminum, 4 point screw mount with 1/8" clear plexi-glass cover.

2.7 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:
1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 7 by 10 inches (180 by 250 mm).

D. Metal-Backed, Butyrate Warning Signs:
1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 10 by 14 inches (250 by 360 mm).

E. Warning label and sign shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2.8 RECEPTACLE AND SWITCH IDENTIFICATION LABELS

A. Materials (Where engraved device faceplates are not used)
1. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Overlay shall provide a weatherproof and UV-resistant seal for label.

B. Identification
1. Label normal receptacle and switch cover plates with the circuit number supplying them below the device using 3/16" high, black filled letters.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.2 EQUIPMENT IDENTIFICATION:

A. Label and mark equipment per all applicable codes.

B. On each unit of equipment, install unique designation nameplate that is consistent with naming used in wiring diagrams, schedules, and the Operation and Maintenance Manual.

C. In addition to equipment listed in Part 2 provide nameplates for:
1. Access doors for concealed electrical devices
2. Transformers
3. Substations
4. Enclosed over-current protective devices
5. Electrical cabinets, enclosures and terminal cabinets
6. Contactors
7. Variable speed drives
8. Battery -inverters, battery racks, UPS equipment
9. Power-generating units
10. Monitoring and control panels and equipment
11. <insert equipment>

D. .

E. Labeling Instructions:
1. Indoor Equipment: Adhesive film label with clear protective overlay
2. Outdoor Equipment: Engraved, laminated acrylic or melamine label with screw fasteners
3. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
4. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

3.3 CIRCUIT CONDUCTOR IDENTIFICATION

A. Power-Circuit Conductor Identification, 600 V or Less:
1. For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
2. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.
   a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
   b. Colors for 208/120-V Circuits:
      1) Phase A: Black.
      2) Phase B: Red.
      3) Phase C: Blue.
      4) Neutral: White
      5) Equipment Ground: Green
      6) Isolated Ground: Green with yellow tracer
   c. Colors for 480/277-V Circuits:
      1) Phase A: Brown.
      2) Phase B: Orange.
      3) Phase C: Yellow.
      4) Neutral: Gray
      5) Equipment Ground: Green
      6) Isolated Ground: Green with yellow tracer
   d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

3. Conductors to Be Extended in the Future: Attach self adhesive label to conductors and list source.

B. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

3.4 WORKING CLEARANCE IDENTIFICATION

A. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated.

B. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

3.5 UNDER GROUND LINE IDENTIFICATION

A. Locations of Underground Lines: Identify with underground-line warning tape for power, light and communication.

1. Install underground-line warning tape for direct-buried cables, cables in raceway and duct banks..

B. Underground-Line Warning Tape Installation: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches (400 mm) overall.

3.6 POSTED DRAWINGS AND OPERATING INSTRUCTIONS

A. Mount drawings and operating procedures on the wall immediately adjacent to the main piece of equipment for which the instructions apply. If sufficient wall space is available, mount directly to one of the sheet metal panels of the equipment.

B. Color Coding Sign: Install instructional sign for the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

C. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

D. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer..

End of Section

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Section 26 05 73

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY AND ARC FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:
   1. Computer-based, overcurrent protective device coordination studies to determine system available short circuit current, minimum interrupting capacity of circuit protective devices, and to determine overcurrent protective device settings for selective tripping.
   2. Arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals may be in digital form.

1. Study input data, including completed computer program input data sheets.
2. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study and arc-flash hazard analysis report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS260573-1.4-B-3-a

A. Qualification Data: For Study Specialist.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. The following parts from the Protective Device Coordination Study Report:

1) The study should include all as-built changes made through the construction process which impact any of the equipment included in the study.
2) One-line diagram (both of the SKM model and the as-built Construction Drawing one-line).
3) Arc flash analysis report and warning labels.
4) Protective device coordination study.
5) Equipment evaluation study.
6) Motor starting and volt drop calculations.
7) Time-current coordination curves.

b. Power system data.

c. The SKM software file(s) and all associated equipment library files used to generate the power system study.

B. Drawings
1. Provide two sets of one or more 24”x48” (minimum) drawings depicting the as-built Construction Documents power one-line drawings mounted on foam board

and framed with an overall plastic cover. Provide quantity of drawings as required to fully depict the system. Drawings should be computer generated AutoCAD or equal with no hand-markings. Locate on set in the main electrical room and another in the main emergency electrical room.

2. Provide electronic format of the above mentioned drawing in a format suitable for use by the Owner. Review acceptable file formats with the Owner prior to submitting drawings.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers: Subject to compliance with requirements, provide software by the following:

1. SKM Systems Analysis, Inc.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Additional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.
6. NMR and scope equipment connections.

D. Study Input Data: As described in "Power System Data" Article.

E. Comments and recommendations for system improvements, where needed.

F. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

G. Short-Circuit Study:

1. Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Calculated asymmetrical fault currents:

1) Based on fault-point X/R ratio.
2) Based on calculated symmetrical value multiplied by 1.6.
3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

a. Phase and Ground Relays:

1) Device tag.
2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
3) Recommendations on improved relaying systems, if applicable.

b. Circuit Breakers:

1) Adjustable pickups and time delays (long time, short time, ground).
2) Adjustable time-current characteristic.
3) Adjustable instantaneous pickup.
4) Recommendations on improved trip systems, if applicable.

c. Fuses: Show current rating, voltage, and class.

I. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination to 0.01 seconds for emergency and legally required systems and 0.1 seconds for normal and optional standby systems. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:

    a. Power utility's overcurrent protective device.
    b. Medium-voltage equipment overcurrent relays.
    c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    f. Cables and conductors damage curves.
    g. Ground-fault protective devices.
    h. Motor-starting characteristics and motor damage points.
    i. Generator short-circuit decrement curve and generator damage point.
    j. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Clearly indicate on all time current curves when selectivity is obtained based on circuit breaker dynamic impedance. Provide manufacturer’s documentation showing testing and verification of all breakers coordinated with dynamic impedance.
7. Comments and recommendations for system improvements.
8. Provide verification of circuit breaker coordination (include verification confirmation of coordination time ranges indicated above) from manufacturer where coordination is based on dynamic impedance or tested values and coordination is not readily apparent from provided time current curves. Indicate source of coordination information (including coordinated time range) on all graphs where coordination is not readily apparent by inspection.

2.3 SHORT-CIRCUIT STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.

2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

F. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.4 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Flash protection boundary.
4. Hazard risk category.
5. Incident energy.
6. Working distance.
7. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. All circuit breakers and fuses are to be coordinated.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less..

E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

F. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

a. Inrush current when first energized.
b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

G. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.

H. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

I. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

J. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

K. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Incoming switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.
5. Motor-control centers.
6. Control panels.
7. Standby generators and automatic transfer switches.
8. Branch circuit panelboards.
9. Disconnect switches.
10. NMR and scope equipment connections.

L. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.

3.3 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:

1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.4 MOTOR-STARTING STUDY

A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.

B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

3.5 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Use the short-circuit study output and the recommended settings of the overcurrent devices.

C. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts. This includes all medium and low-voltage switchgear, unit-substations, switchboards, panelboards, and motor-starters/disconnects/VFDs.

E. Include medium- and low-voltage equipment locations.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.6 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 241 and IEEE 551 for the amount of detail required to be acquired.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
17. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.
    e. Ratings, types, and settings of utility company's overcurrent protective devices.
    f. Special overcurrent protective device settings or types stipulated by utility company.
    g. Time-current-characteristic curves of devices indicated to be coordinated.
    h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.

i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.7 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and 208-V ac panelboards and disconnects and for each of the following locations:

1. Motor-control center.
2. Low-voltage switchboard.
3. Low-voltage unit substations.
4. Low and Medium-voltage Switchgear.
5. Medium-voltage switch.
6. Control panel.
7. Panelboards
8. Motor-starters
9. Disconnects
10. VFDs.

3.8 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.9 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.10 DEMONSTRATION

A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
3. Adjust, operate, and maintain overcurrent protective device settings.
4. The potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

End of Section

SECTION 26 08 00
ELECTRICAL SYSTEM COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes: The Work of this Section shall include but not be limited to the following:

1. Systems and equipment Start-Up and Functional Performance Testing.
2. Validation of proper and thorough installation of Division 26 systems and equipment.
3. Generic Start-Up Documentation for electrical systems and equipment.
4. Development of final Start-Up Documentation for electrical systems and equipment.
5. System Start-Up and Turn-Over procedures.
6. Coordination and execution of Training Events.

B. Related Work and Documents

1. The Cx process references many related Sections, particularly Section 01 91 00 - General Commissioning. It is important for all Contractors subject to the Cx process to be familiar with Section 01 91 00.
2. Refer to Section 01 91 00 for a complete list of Sections on Related Work.

1.3 GENERAL DESCRIPTION

A. Commissioning (Cx) is the process of ensuring that (i) all building systems are installed and perform interactively according to the design intent; (ii) that systems are efficient and cost effective and meet the Owner’s operational needs; (iii) that the installation is accurately documented; and (iv) that the Operators are adequately trained. Commissioning serves as a tool to minimize post-occupancy operational problems, and establishes testing and communication protocols to advance the building systems from installation to optimized, fully-dynamic operation.

B. Commissioning Authority (CxA) shall work with the Contractor and the design engineers to direct and oversee the Cx process and perform Functional Performance Testing.

C. The Commissioning Plan outlines the Cx process beyond the Construction Contract, including design phase activities and design team/owner responsibilities. The specification Sections dictate all requirements of the commissioning process relative to the construction contract. The Cx Plan is not part of the construction contract, although it is available for reference at the request of the Contractor.

D. This Section outlines the Cx procedures specific to the Division 26 Contractors. Requirements common to all Sections are specified in Sections 01 91 00 and 01 91 10 This Section and other sections of the specification details the Contractor's responsibilities relative to the Cx process.

1.4 SCOPE

A. The following systems and equipment are included in the Scope of Commissioning for this project:

B. Electrical Systems: All Division 26 equipment and systems are subject to commissioning, including but not limited to the systems listed below. All components and devices that make up these systems are included.

1. Grounding Equipment and Building Grounding System
2. Disconnect Switches
3. Circuit Breakers
4. Motor Controllers
5. Distribution Dry-Type Transformers
6. Distribution and Branch Circuit Panelboards
7. Automatic Transfer Switches
8. Feeders and Large Branch Circuits
9. Branch Circuits and Receptacles
10. Lighting and Lighting Controls
11. Lightning Protection System
12. Fire Alarm System/Equipment
13. Motors

1.5 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 01 91 00 for a complete list of Definitions and Abbreviations.

1.6 REFERENCE STANDARDS

A. National Electric Code (NEC)

B. American Society for Testing and Materials (ASTM)

C. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA)

D. Illuminating Engineering Society (IES)

E. Institute of Electrical and Electronics Engineers (IEEE)

F. International Electrical Testing Association (NETA)

G. National Electrical Manufacturers Associates (NEMA)

H. National Fire Protection Association (NFPA)

I. Underwriters Laboratory, Inc. (UL)

J. Refer to Section 01 91 00 for additional Reference Standards.

1.7 DOCUMENTATION

A. Documentation shall be as required in Section 01 91 00. In addition, Contractor shall also provide to the CxA the following per the procedures specified herein, in the Cx Plan, and in other Sections of the specification:

1. Short Circuit and Coordination Study: CxA shall review and recommend approval.

2. Factory Test Reports: Contractor shall provide any factory testing documentation or certified test reports required by the specifications. These shall be provided prior to Acceptance Phase. Factory Test Reports shall be provided in PDF electronic format.

3. Field Testing Agency Reports: Provide all documentation of work of independent testing agencies required by the specification. These shall be provided prior to Acceptance Phase. Field Testing Agency Reports should be provided in PDF electronic format. These may include but are not limited to:

a. Electrical Testing Agency Reports

b. Thermographic Survey Report

c. Other

4. Sample of distribution panel and receptacle labeling for approval.

5. Fire Alarm System Approvals and Certifications.

1.8 SEQUENCING AND SCHEDULING

A. Refer to Section 01 91 00.

1.9 COORDINATION MANAGEMENT PROTOCOLS

A. Coordination responsibilities and management protocols relative to Cx are initially defined in Section 01 91 00 and the Cx Plan, but shall be refined and documented in the Construction Phase Cx Kick-Off Meeting. Contractor shall have input into the protocols to be used and all Parties will commit to scheduling obligations. The CxA will record and distribute.

1.10 CONTRACTOR RESPONSIBILITIES

A. Refer to Section 01 91 00: Detailed Contractor responsibilities common to all Divisions are specified in Section 01 91 00. The following are additional responsibilities or notable responsibilities specific to Division 26.

B. Construction Phase

1. Provide skilled technicians qualified to perform the work required.

2. Provide factory-trained and authorized technicians where required by the Contract Documents.
3. Prepare and submit required draft Start-Up Documentation and submit along with the manufacturer's application, installation and start-up information.
4. Provide assistance to the CxA in preparation of the specific Functional Performance Test (FPT) procedures. Contractors, subcontractors and vendors shall review FPT procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests. Damage caused to equipment performed in accordance with the approved procedures will be the responsibility of the Contractor.
5. Thoroughly complete and inspect installation of systems and equipment as detailed throughout Contract Documents, as required by reference or industry standards, and as specifically indicated elsewhere this Section.
6. Start-Up, Adjust, Test, and Turn-Over systems and equipment prior to functional performance testing by the CxA. Approved Start-Up Documentation shall be in accordance with Contract Documents, reference or industry standards, and specifically elsewhere in Part I of this Section.
7. Record Start-Up on approved Start-Up Documentation forms and certify that the systems and equipment have been started and or tested in accordance with the requirements specified above and in Section 01 09 00. Each task or item shall be indicated with the Party actually performing the task or procedure.
8. Coordinate the work of the Electrical Testing Agency and the Cx requirements.
9. Coordinate the checkout of the Fire Alarm System and the approval of the regulatory authorities with the Cx process.

C. Acceptance Phase

1. Assist CxA in Functional Performance Testing. Assistance will typically include the following:
2. Manipulate systems and equipment to facilitate Functional Performance Testing (as specified in Section 01 91 00, Section 01 91 10, and the Cx Plan; in some cases this will entail only an initial sample);
3. Provide any specialized instrumentation necessary for Functional Performance Testing;

1.11 EQUIPMENT SUPPLIER RESPONSIBILITIES

A. Refer to Section 01 91 00.

1.12 CONTRACTOR NOTIFICATION AND SCHEDULING

A. Refer to Section 01 91 00.

1.13 START-UP DOCUMENTATION

A. Refer to Section 01 91 00.

1.14 EQUIPMENT NAMEPLATE DATA

A. Refer to Section 01 91 00.

1.15 INDEPENDENT ELECTRICAL TESTING AGENCY

A. An Independent Electrical Testing Agency shall be provided under the construction specifications and therefore included with the bid. Many of the aspects of the Start-Up and Functional Performance Testing indicated herein will be accomplished under the respective section and witnessed by the CxA at the indicated sample rate. CxA will include applicable test results in the functional performance testing record.

1.16 FUNCTIONAL PERFORMANCE TESTING

A. For applicable systems and equipment, Contractor shall participate in the initial samples of Functional Performance Testing as stipulated in Section 01 91 00 and Section 01 91 10.

1.17 FPT ACCEPTANCE CRITERIA

A. Acceptance criteria for tests are indicated in Section 01 91 10 and in the specification Sections applicable to the systems being tested. Unless indicated otherwise, the criteria for acceptance will be that specified with the individual system, equipment, component, or device, which shall typically conform to NFPA 70B and International Electrical Testing Association (NETA) testing specifications NETA ATS-1991.

1.18 TRAINING

A. Contractors, subcontractor, vendors, and other applicable Parties shall prepare and conduct training sessions on the installed systems and equipment they are responsible for per the requirements of Section 01 91 00 and the individual Specifications.

1.19 SYSTEMS MANUAL AND O&M DOCUMENTATION CONTENT - PREPARATION AND LOGISTICS

A. Refer to Section 01 91 00 the individual Specifications.

B.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

A. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. Unless otherwise noted, all equipment shall be calibrated according to the manufacturer’s recommended intervals. Calibration tags shall be affixed or certificates readily available.

B. Testing Instrumentation: Contractor shall provide all instrumentation necessary for tests for which they are responsible. CxA will provide standard instrumentation for measuring medium and low voltage electrical voltage, current, power factor, power, and total harmonic distortion (THD). CxA

will provide receptacle testers for normal and GFI receptacle tests. Contractor shall provide all other instrumentation required to accomplish the specified testing.

2.2 INFRARED THERMOGRAPHIC SCANNER

A. Contractor shall provide infrared scanning equipment. Infrared scanning equipment shall be an AGA (or approved equal) thermovision set capable of viewing an entire bus or equipment assembly at one time and have a sensitivity of 0.2°C with a liquid nitrogen reference.

2.3 WEB-BASED COMMISSIONING PORTAL

A. All general and major subcontractors participating in the Cx process shall use the web-based Cx Portal ('Portal') to document the Cx procedures. The Portal is a Web-based Internet hub used to electronically collaborate and coordinate activities and deliverables throughout the Cx process. The Portal is hosted by the CxA and shall be accessible to all Parties participating in the Cx program. The Portal provides a common location to store Start-Up Documentation, Functional Performance Tests and results, project documents and deliverables. It also serves as a collaborative email hub to facilitate, automate, and track communications between Parties relating to the Cx process.

B. Refer to Section 01 91 00 the individual Specifications for additional information and requirements for using the Portal.

PART 3 - EXECUTION

3.1 GENERIC START-UP DOCUMENTATION - GENERAL

A. Part III of this Section outlines 'generic' or minimally acceptable Start-Up Documentation (which are defined to include both 'Start-Up Checks' and 'Start-Up Tests') and individual systems training requirements for systems and equipment. These procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct per normal quality control practices. These items shall provide a minimally acceptable guideline for required Contractor development of Start-Up Documentation. Contractor shall synthesize these minimum requirements along with their own internal quality control practices, those of the manufacturer, and any applicable codes and standards to develop specific and itemized final Start-Up Documentation specific to the equipment and systems installed on this project.

B. Section 01 91 00 defines the systems and equipment Start-Up process in detail and provides definitions for Start-Up Documentation, including the generic Start-Up Documentation provided below.

3.2 TESTING PROCEDURES

A. Thermographic Scanning

1. The infrared scan shall be made when the equipment is energized and is operating at its normal capacity, unless otherwise noted. It is intended that the scan be made after the equipment has been in full operation; however, the exact time of conducting the scan will be determined by the CxA near the completion of the project.

2. Test equipment, miscellaneous tools, and materials shall be transported properly, moved, and set up by trained personnel. Equipment used in testing shall be capable to perform all recommended procedures required by the apparatus and related equipment. All test equipment shall have certification of calibration and be in working order.
3. All hot spots shall be marked, identified and an infrared thermographic scanning report prepared and furnished to the Owner.
4. The report shall contain infrared photos of trouble spots with temperature readings.
5. All sources indicating heat problems shall be promptly reported to the Owner for corrective action by the Division 26 contractor.

B. Grounding Systems

1. Perform three-point fall-of-potential test per IEEE Standard 81 on the main grounding electrode or system. Resistance shall be no greater than 5 ohms.
2. Perform the two-point method test per IEEE Standard 81 to determine the ground resistance between the main ground system and all major electrical equipment frames, system neutral, and/or derived neutral points. Resistance shall be no greater than 5 ohms.

3.3 START-UP CHECKS COMMON TO ALL SYSTEMS

A. The following Start-Up verifications and procedures shall be considered common to all systems:

1. Checkout shall proceed from lower level devices to larger components to the entire system operation.
2. Verify labeling is affixed per specification and visible.
3. Verify prerequisite procedures are done.
4. Inspect for damage and ensure none is present.
5. Verify system is installed per the manufacturer’s recommendations.
6. Verify system has undergone Start-Up per the manufacturer’s recommendations.
7. Verify that access is provided for inspection, operation and repair.
8. Verify that access is provided for eventual replacement of the equipment.
9. Verify that record drawings, submittal data and O&M documentation accurately reflect the installed systems.
10. Verify all gauges and test ports are provided as required by contract documents and manufacturer’s recommendations.
11. Verify all recorded nameplate data is accurate.
12. Verify that the installation ensures safe operation and maintenance.
13. Verify specified replacement material/attic stock has been provided as required by the Contract Documents.
14. Verify all rotating and moving parts are properly lubricated.

15. Verify all monitoring and ensure all alarms are active and set per Owner's requirements.
16. Complete all nameplate data and confirm that ratings conform to the design documents.

3.4 GROUNDING/BUILDING GROUNDING SYSTEM

A. Include all applicable 'Start-Up Checks Common to All Systems". Additional Start-Up Checks and Tests are as follows.

B. General: Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.

1. Conduct fall of potential ground resistance tests per IEEE Standard 81 at each test well and at service equipment.
2. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.

3.5 DISCONNECT SWITCHES

A. Include all applicable 'Start-Up Checks Common to All Systems". Additional Start-Up Checks and Tests are as follows.

B. General: Refer to the quality control requirements listed in applicable Sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer's instructions.

1. Visual and Mechanical Inspections listed in NETA 7.5.1.1.1.
2. Check installation of warning nameplates and equipment nametags.

D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.

1. Electrical tests listed in NETA 7.5.1.1.2.

E. Training: Train Owner's maintenance personnel on procedures and schedules related to troubleshooting, servicing, and preventative maintenance.

3.6 CIRCUIT BREAKERS

A. Include all applicable 'Start-Up Checks Common to All Systems". Additional Start-Up Checks and Tests are as follows.

B. General: Provide the services of a manufacturer-certified specialist to supervise the installation, make adjustments, and perform tests on the insulated case breakers, power breakers and medium-voltage breakers and train Owner's maintenance personnel. Refer to the quality control

requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer's instructions.

1. Visual and Mechanical Inspections listed in NETA 7.6.1.1.1 insulated case and molded case breakers, NETA 7.6.1.2.1 for low-voltage power breakers, and NETA 7.6.1.3.1 for medium-voltage air breakers.

D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.

1. Electrical tests listed in NETA 7.6.1.1.2 insulated case and molded case breakers, NETA 7.6.1.2.2 for low-voltage power breakers, and NETA 7.6.1.3.2 for medium-voltage air breakers. Optional tests are not required.

E. Training: Train Owner's maintenance personnel on procedures and schedules related to troubleshooting, servicing, and preventative maintenance.

3.7 MOTOR CONTROLLERS

A. Include all applicable 'Start-Up Checks Common to All Systems". Additional Start-Up Checks and Tests are as follows.

B. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer's instructions.

1. Visual and Mechanical Inspections listed in NETA 7.16.1.1.1, including optional items.

2. Check installation of warning nameplates and equipment nametags.

D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.

1. Visually and mechanically inspect to include the following: anchoring, grounding, torque of feeder and incoming connections, electrical clearances, starter and feeder unit drawout mechanisms, and check installation using manufacturer's checklist.

2. Electrical tests listed in NETA 7.16.1.1.2. Optional tests are not required.

E. Training: Train Owner's maintenance personnel on procedures and schedules related to troubleshooting, servicing, and preventative maintenance.

3.8 DISTRIBUTION DRY-TYPE TRANSFORMERS

A. Include all applicable 'Start-Up Checks Common to All Systems". Additional Start-Up Checks and Tests are as follows.

B. General: Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer's instructions.

1. Inspect wiring connections.
2. Insure taps are adjusted.
3. Inspect grounding.

D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.

1. Visually and mechanically inspect to include the following: mounting, grounding, electrical clearances, and K-factor and/or isolating transformers are installed where required.
2. Perform insulation resistance, turns ratios, and polarity tests on each type /size of transformer.

E. Training: Train Owner's maintenance personnel on procedures and schedules related to troubleshooting, servicing, and preventative maintenance.

3.9 DISTRIBUTION AND BRANCH CIRCUIT PANELBOARDS

A. Include all applicable 'Start-Up Checks Common to All Systems". Additional Start-Up Checks and Tests are as follows.

B. General: Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer's instructions.

1. Visually and mechanically inspect to include the following: mounting, separate ground and neutral connections per circuit, completed circuit directories, electrical clearances, KAIC ratings of panelboard and breakers.
2. Inspect wiring connections.

D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.

1. Correct surge suppression devices installed.
2. Conduct insulation resistance tests.
3. Correct identification and phasing arrangements.
4. Verify the printed panel board directory matches the branch circuit labeling.

3.10 AUTOMATIC TRANSFER SWITCHES (ATS)

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Provide the services of a manufacturer-certified specialist to supervise the installation, make adjustments, perform tests on the automatic transfer switches, and train Owner's maintenance personnel. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer’s instructions.

1. Visually inspect the systems.
2. Ensure the terminations are tight and all ancillary equipment completely installed.
3. Ensure all overloads are in place.

D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer’s instructions.

1. Electrical tests listed in NETA 7.22.3.2.

E. Training: Train Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance.

3.11 FEEDERS AND LARGE BRANCH CIRCUITS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: This paragraph and subparagraphs apply to all feeders serving panelboards, and motor control centers, all conductors connected to switchgear and switchboards, and all circuits that are rated for 100 amps, or larger. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer’s instructions.

1. Inspect cable support and terminations.
2. Verify equipment edges are not in contact with cables or that protective padding is provided.
3. Visually and mechanically inspect to include the following: large junction and pull boxes, supports of raceways and cable bus, and compression type terminations.
4. Torque test terminations and verify they are in accordance with manufacturers recommendations.
5. Correct identification and phasing arrangements.

D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.

1. Verify cable size and ratings match single-line diagram. Verify correct overcurrent protection.
2. Torque test terminations and verify they are in accordance with manufacturers recommendations.
3. Correct identification and phasing arrangements.
4. Conduct continuity test of each feeder.
5. Conduct insulation resistance test on each cable with respect to ground and adjacent cables.

3.12 LIGHTING CONTROLS

A. Include all applicable 'Start-Up Checks Common to All Systems". Additional Start-Up Checks and Tests are as follows.

B. General: Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer's instructions.

1. Ensure all labeling for all relays/contactors is affixed and accurate.
2. Ensure all terminations are tight.
3. Check sensor placement is adequate for required duty.
4. Ensure adequate access is provided to all relays/contactors, timeclocks, etc.
5. Ensure all circuits for the loads are energized and ready for testing.
6. Obtain all time schedules and individual device time-delay settings for all spaces from the Owner.

D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.

1. Test, calibrate, and set all sensing (photocells, motion sensors, etc.) devices.
2. Verify the correct operation of all control devices (contactors, relays, timeclocks, BAS interface relays, etc.).
3. Check full load current on all breakers serving controlled lighting to ensure that the breaker is properly sized.
4. Check full load current on all control device contacts serving controlled lighting to ensure that the contact rating is properly sized.
5. Enter all time schedules per Owner's direction. Individual device time-delay settings are handled as part of the Room/Zone Checkout described in this Section.

6. Validate all interfaces with other systems on a point-by-point basis.

E. Training: Train Owner's maintenance personnel on the operation, programming and maintenance of the lighting controls.

3.13 LIGHTING CONTROL SYSTEMS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Provide the services of a factory-trained manufacturer’s representative to assist the Contractor in the installation and start-up service of the lighting control system and train Owner's maintenance personnel as specified below. Representative will confirm the proper installation and operation of all system components. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer’s instructions.

1. Ensure all labeling is affixed and accurate.
2. Ensure all terminations are tight.
3. Check sensor placement is adequate for required duty.
4. Ensure adequate access is provided to all panels and that documentation of that panel is provided in it.
5. Ensure all circuits for the loads are energized and ready for testing.
6. Obtain all time schedules, individual device time-delay settings for all spaces, and on/off fade-rate settings from the Owner.

D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer’s instructions.

1. Test, calibrate, and set all digital and analog sensing, and actuating devices. Calibrate each instrumentation device by making a comparison between the graphic display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range). Record the measured value and displayed value for each device in the Start-Up Report.
2. Check each digital control point by making a comparison between the control command at the control panel and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the OI display. Record the results for each device in the BAS Start-Up Report.
3. Check full load current on all breakers serving controlled lighting to ensure that the breaker is properly sized.

4. Check full load current on all control device contacts serving controlled lighting to ensure that the contact rating is properly sized.
5. Enter all time schedules, override time-delays and on/off fade rates per Owner’s direction.
6. For Operator Interfaces:
    a. Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.
    b. Output all specified reports for review and approval.
    c. Verify the alarm printing and logging is functional and per requirements.
7. Validate all interfaces with other systems on a point-by-point basis.

E. Training: Train Owner's maintenance personnel on the operation and programming of the lighting control system. Two days of training will be provided for up to 12 users.

3.14 LIGHTNING PROTECTION SYSTEM

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer’s instructions.

1. Review UL test certification.
2. Check for receipt of UL master label.

3.15 FIRE ALARM SYSTEM/EQUIPMENT

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Provide the services of a qualified fire alarm specialist to supervise the installation, make adjustments, and perform tests on the fire alarm system and train Owner's maintenance personnel. Refer to the quality control requirements listed in applicable sections of Division [28] [26] for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer’s instructions.

1. Ensure all labeling is affixed and accurate.
2. Ensure all terminations are tight.
3. Ensure adequate access is provided to all panels and that documentation of that panel is provided within.

4. Review that all fire alarm devices as shown on the construction drawings and shop drawings are installed.
5. Review height and locations of all pull stations and visual alarms to comply with ADA.
6. Review that all smoke and duct detectors are installed according to NFPA 72E and NFPA 90A.
7. Check that fire alarm system control panel is clear with no trouble or ground faults.
8. Verify all sprinkler flow and tamper switches have been adjusted.
9. Check wire supervision on all devices.

D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.

1. Check location of all sensors and switches to ensure conformance with requirements.
2. Activate all devices, and assure alarms are initiated and resulting response is per the requirements.
3. Verify interfaces with all other inter-related systems or equipment including BAS, sound systems, security systems, HVAC systems, vertical delivery systems, etc. on a point-by-point basis for all points.
4. Verify sound level in all spaces, with doors and windows closed, is at least 15dBa above ambient level with a minimum level of 85dBa. If voice alarm messages are transmitted, verify that speech is intelligible in all spaces. Perform testing in each space only after all penetrations of partitions have been sealed in accordance with contract requirements.
5. Verify that visual alarm devices are directly visible throughout egress paths, assembly spaces, public waiting areas, and public toilets.
6. Activate high temperature detectors in the elevator machine room. Verify all sequences including elevator shunt off, elevator recall including alternate floors when main floor is in alarm.
7. Activate all sprinkler flow switches. Validate that appropriate zone enunciates and alarms sound.
8. For enunciator panels, validate correct graphic and correct identification of all zones. Test the action and interlocks of all override switches as appropriate.
9. For Operator Interfaces:
    a. Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.
    b. Output all specified reports for review and approval.
    c. Verify the alarm printing and logging is functional and per requirements.
10. Validate all interfaces with other systems on a point-by-point basis.
11. Obtain written approval from the Authority Having Jurisdiction (AHJ).

E. Demonstration/Certification Procedures:

1. After the system has been fully started and checked out and all record drawings are revised to match actual conditions, submit a request for local authority approval/certification at least two weeks in advance of the proposed date.
2. Follow local authority Process to request the certification which includes submitting record drawings and system checkout documentation.
3. Demonstrate actuation of every device (pull switches, smoke detectors, heat detectors, flow switches, etc.) and resulting sequence to local authority representative during the certification.
4. Demonstrate all communications capabilities.

F. Training: Train Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance.

3.16 MOTORS

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. General: Electrical contractor shall check for adequate electrical connection for each motor. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.

C. Start-Up Checks and Tests: Follow the manufacturer's written procedures and the following as a minimum:

1. Inspect terminations and grounding.
2. Ensure proper access to all electrical equipment.
3. Ensure proper labeling of all electrical equipment.
4. Compare wiring of poles to manufacturer’s instructions.
5. Check voltage-to-disconnects with disconnect open and compare to rating data.
6. In collaboration with the Contractor who supplied the motor, bump it and ensure proper rotation.
7. Test each motor with megger and record readings. Megger test shall be performed at the final disconnect switch/breaker for the motor.
8. Check the overloads in comparison to FLA noted on the motor nameplate and ensure adequacy of protection and reliability.
9. Observe several starts to ensure the start is reliable.

3.17 ROOM/ZONE CHECKOUT

A. Include all applicable ‘Start-Up Checks Common to All Systems”. Additional Start-Up Checks and Tests are as follows.

B. Contractor shall complete a checklist acknowledging completion of Div. 26 responsibilities for all rooms. Checklist shall include items such as the following as applicable:

C. Typical Room:

1. Receptacle covers on, clean and labeled.
2. Test every receptacle installed or reconnected under this contract with a receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and retest.
3. Test each receptacle or branch circuit breaker having ground-fault circuit protection to assure that the ground-fault circuit interrupter will operate when subjected to a ground-fault current exceeding 5 mA within 1/40th of a second. Perform testing using an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. "TEST" button operation shall not be acceptable as a substitute for this test. Replace receptacles that do not shut off power within the specified time limit and retest.
4. Visually and mechanically inspect raceways to include the following: large junction and pull boxes, supports of raceways, & compression type terminations.
5. Visually inspect the wiring connections and splices in surface wireways. Confirm that splices are adequately insulated and performed using components approved for the quantity of conductors included in the splice.
6. Light fixture in place and clean with lamps installed.
7. All lighting control devices checked for operation and labeling.
8. Verify that all occupancy sensors are installed according to manufacturer's recommendations to avoid incorrect cycling of light fixtures (motion outside of space causes lights to turn on, air discharging from ceiling registers causes lights to turn on, etc.)
9. Adjust occupancy sensor time delay according to Owner's instructions. Record the adjustment.

D. Rooms with Fire Alarm Devices:

1. Fire alarm sensors and enunciators in place and validated.

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SECTION 261116

SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes indoor secondary unit substations, each consisting of the following:

1. Primary incoming section.
2. Transformer.
3. Secondary distribution section.

B. Related Sections include the following:

1. Section 260513 "Medium-Voltage Cables" for requirements of terminating cables in incoming section of substation.
2. Section 260573 "Overcurrent Protective Device Coordination Study And Arc Flash Hazard Analysis" for short-circuit rating of devices, setting of overcurrent protective devices and arc flash hazard analysis.
3. Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" for transient voltage surge suppressors for low-voltage power, control, and communication equipment that may be located in secondary section.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Dimensioned plans and elevations showing major components and features.
3. One-line diagram.

4. List of materials.
5. Nameplate legends.
6. Size and number of bus bars and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
7. Short-time and short-circuit current ratings of secondary unit substations and components.
8. Ratings of individual protective devices.

C. Time-Current Characteristic Curves: For overcurrent protective devices.

D. Primary Fuses: Submit recommendations and size calculations.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Dimensioned concrete base, outline of secondary unit substation, conduit entries, ground rod and ground wire locations.
2. Location of structural supports for structure-supported raceways, busways.
3. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

B. Qualification Data: For testing agency.

C. Product Certificates: For secondary unit substations, signed by product manufacturer.

D. Factory test reports.

E. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare fuses: Six of each type and rating of fuse and fusible device used, except for medium-voltage fuses. Include spares for the following:

a. Primary disconnect fuses.
b. Potential transformer fuses.
c. Control power fuses.
d. Fuses and fusible devices for fused circuit breakers.

e. Fuses for secondary fusible devices.

2. Spare Indicating Lights: Six of each type installed.
3. Touchup Paint: Three half-pint containers of paint matching enclosure's exterior finish.
4. Primary Switch Contact Lubricant: One container(s).
5. One set of spare mounting gaskets for bushings, handholes, and the gasket between relief cover and flange of pressure relief device.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain secondary unit substation through one source from a single manufacturer.

C. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C2.

E. Comply with IEEE C37.121.

F. Comply with NFPA 70.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of secondary unit substations to allow movement into designated space.

C. Store secondary unit substation components protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

D. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.

1.10 PROJECT CONDITIONS

A. Field Measurements: Indicate measurements on Shop Drawings.

B. Service Conditions: IEEE C37.121, usual service conditions, except for the following:

1.11 COORDINATION

A. Coordinate layout and installation of secondary unit substations with other construction that penetrates floors and ceilings, or is supported by them, including light fixtures, HVAC equipment, and fire-suppression-system components.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cutler-Hammer, Inc.; Eaton Corporation.
2. GE Electrical Distribution & Control.
3. Square D; Schneider Electric.

2.2 MANUFACTURED UNITS

A. Indoor Unit Arrangement: Single assembly.

B. Enclosure Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.3 INCOMING SECTION

A. Phase Barriers: Located between blades and fuses of each phase, designed for easy removal, allows visual inspection of switch components when barrier is in place.

B. Window: Permits viewing switch-blade positions when door is closed.

C. IR Scanning Window: Provide IR scanning window to allow all cable terminations to be scanned without the need to open the enclosure. Provide window type which is compatible with Owner’s IR scanning equipment.

D. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include fuse-handling tool as recommended by switchgear manufacturer.

E. Continuous-current and short-circuit ratings listed below are for commonly available switches; adjust if required to suit Project conditions.

F. Continuous-Current Rating: 600 A.

G. Short-Circuit Rating:

1. Short-time momentary asymmetrical fault rating of 40 kA.
2. 3-second symmetrical rating of 25-kA RMS.
3. Fault close asymmetrical rating of 40 kA.

H. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading. Comply with the following:

1. Current-limiting type, rated for not less than 50-kA RMS symmetrical current-interrupting capacity.
2. Indicator integral with each fuse to show when it has blown.

I. Spares: Include three fuses in use and three spare fuses in storage clips in each switch.

J. Surge Arresters: Comply with IEEE C62.11, Distribution class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.

K. Phase- Bus Material: Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.

2.4 DRY-TYPE TRANSFORMER SECTION

A. Description: IEEE C57.12.01, IEEE C57.12.50 or IEEE C57.12.51, NEMA ST 20, and dry-type, 2-winding, secondary unit substation transformer.

B. Enclosure: Indoor, ventilated, vacuum pressure impregnated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with a dual 80 deg C /115 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

C. Cooling System: Class AA, air cooled FA, air cooled with forced-air rating and dual temperature rise as indicated on drawings, complying with IEEE C57.12.01.

1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
2. Include mounting provision for fans for AA transformers.

D. Insulation Materials: IEEE C57.12.01, rated 185 deg C.

E. Insulation Temperature Rise: 80/115 deg C (dual rise), maximum rise above 40 deg C.

F. Primary Basic Impulse Level: 95 kV.

G. Secondary Basic Impulse Level: 30 kV.

H. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

I. Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.

J. Sound level may not exceed 66 dB, without fans operating.

K. Impedance: 5.75% percent.

L. Temperature Monitor: Sensor at transformer to measure temperature in each phase plus electrical room ambient temperature. Monitor shall include display screen indicating temperate with local audible and visual alarm. Sensor shall communicate with BAS through substation integrated trip unit metering system. This system shall also allow remote login with TCP/IP for remote temperature monitoring. Sensor shall be Eaton TC-100 meter or approved equal by substation manufacturer.

M. IR Scanning Window: Provide IR scanning window to allow all cable terminations and transformer coils to be scanned without the need to open the enclosure. Provide windows on both sides of the enclosure to facilitate scanning of transformer coils from all sides. Provide window type which is compatible with Owner's IR scanning equipment.

2.5 SECONDARY DISTRIBUTION SECTION

A. Secondary Distribution: Low-voltage switchboard as specified in Section 262413 "Switchboard."

2.6 IDENTIFICATION DEVICES

A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.7 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to ANSI C37.51.

B. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:

1. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
2. Ratios on the rated voltage connection and on tap extreme connections.
3. Polarity and phase relation on the rated voltage connection.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
7. Applied potential.
8. Induced potential.
9. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kVA Class ONAN or Class AA rating and highest kVA Class ONAF or Class AFA rating.
    a. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.
10. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of work.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.

D. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at secondary unit substation location.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install secondary unit substations on concrete bases.

1. Anchor secondary unit substations to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

2. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in all directions, except for front of unit, than supported unit and 4 inches (100 mm) high.
3. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete."
4. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
5. Install epoxy-coated anchor bolts for anchoring equipment to the concrete base.
6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Bolt unit substations to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Section 260553 "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of secondary unit substation.

C. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with single line diagram and approved mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
2. Medium: Laminated plastic strips
3. Color: Shall match the system as specified in Section 260553 "Identification for Electrical Systems" for Northeastern University cubicles/equipment.

3.4 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing. Tests shall include the following at a minimum.

1. Perform each visual and mechanical inspection and electrical test according to NETA ATS. Certify compliance with test parameters.
2. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation tested at the specified value or less.
3. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
4. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

    a. Remove and replace malfunctioning units and retest as specified above.

3.7 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and which log data in an electronic format and a minimum sample rate of 2 MHz speed or equivalent. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

    a. Adjust transformer taps.
    b. Rebalance loads.
    c. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
4. Report: Prepare a written report covering monitoring performed and corrective action taken.

B. Infrared Scanning: Perform as specified in Section 262300 "Low-Voltage Switchgear."

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 261116

Section 26 13 26

MEDIUM-VOLTAGE SWITCHGEAR

PART 1- GENERAL

1.1 SUMMARY

A. This Section specifies requirements for medium voltage metal-clad switchgear.

B. Sections Includes:

1. Switchgear enclosure.
2. Switchgear construction.
3. Surge arresters.
4. Instruments.
5. Protective relays.
6. Control power supply.
7. Battery system control power supply.
8. Control network.
9. Warning labels and signs.

C. Related Sections include the following:

1. Division 26 Section “Common Work Results for Electrical, Communications, and Electronic Safety,” including safety accessories.
2. Division 26 Section "Electrical Power Monitoring and Control" for interfacing communication and metering requirements.

1.2 REFERENCES

A. American National Standards Institute (ANSI)

1. ANSI C37.55 – American National Standard for Switchgear – Metal–Clad Switchgear Assemblies – Conformance Test Procedures

B. Institute of Electrical and Electronic Engineers (IEEE)

1. C37.04 – Standard Rating Structure for AC High-Voltage Circuit Breakers - Description
2. C37.06 – Switchgear - AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Required Capabilities
3. C37.09 – Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4. C37.10 – Application Guide for Power Circuit Breakers.
5. C37.11 – Standard for Power Circuit Breaker Control requirement.
6. C37.20.2 – Amendment 1: Capacitance Current Switching – IEEE Standard for Metal-Clad and Station – Type Cubicle Switchgear (Includes Supplement C37.20.2b

7. C37.20 .7 - Standard for Switchgear Assemblies and Metal-Enclosed Bus
8. C37.21 – Standard for Control Switchboards
9. C37.46 – American National Standard Specifications for Power Fuses and Fuse Disconnecting
10. C37.54 – American National Standard Conformance Test Procedures for Indoor Alternating Current Medium-Voltage Circuit Breakers Applied as Removable Elements in Metal-Enclosed Switchgear
11. C37.60 - Standard for Interrupting factors – Reclosing service
12. C37.90 – Standard for Relays and Relay Systems Associated with Electric Power Apparatus
13. C37.90.1 - Surge Withstand Capability (SWC) tests for Protective Relays and Relay Systems
14. C37.98 - Standard for Seismic Testing of Relays
15. C37.100 - Definitions for Power Switchgear
16. C57.13 – Standard Requirements for Instrument Transformers

C. National Electrical Manufacturers Association (NEMA)

1. ICS2 – Industrial Control and Systems Controllers, Contractors and Overload Relays, Rated 600 Volts
2. ICS4 – Industrial Control and Systems: Terminal Blocks
3. SG4 – Alternating-Current High-Voltage Circuit Breakers
4. SG5 - Power Switchgear Assemblies
5. SG6 - Power Switching Equipment

D. National Fire Protection Agency (NFPA)

1. NFPA 70-National Electric Code

E. Underwriters' Laboratories, Inc. (UL)

1. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
2. UL 508 - Industrial Control equipment
3. UL 1670 Circuit Breakers and Metal-Clad Switchgear – Over 600 volts

F. Consolidate Edison of New York

1. EO-2022 - General Specification for High Tension Service
2. EO-4019 Testing of AC Feeders Operating at 4kV to 35kV
3. City of New York
4. New York City Electrical Code

1.3 SUBMITTALS

A. Product Data: For each type of switchgear and related equipment, including the following:

1. Rated capacities, operating characteristics, furnished specialties, and accessories for individual interrupter switches and circuit breakers.
2. Time-current characteristic curves for overcurrent protective devices,
3. Provide relay monitoring, health, diagnostic and metering points for each relay type, refer to the power monitoring specifications.

B. Shop Drawings: For each type of switchgear and related equipment, including the following:

1. Include a tabulation of installed devices with features and ratings.
2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations shall show major components, features, and mimic bus diagram.
3. Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended work space, and locations of penetrations for grounding and conduits. Show location of anchor bolts and leveling channels.
4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of each field connection.
5. Locate accessory and spare equipment storage.
6. Include single-line diagram.
7. Include control power wiring diagrams.
8. Include batteries, battery rack, equipment base, and room layout.
9. Include copy of nameplate.
10. Test results of enclosure corrosion resistant finish.
11. Ratings the switchgear assembly:
    a. Voltage.
    b. Continuous current.
    c. Short-circuit current.
    d. Lightning impulse full-wave withstand voltage.
12. Utility company's metering provisions with indication of approval by utility company.
13. Relay settings. Provide calculations/graphs showing the CT's will not go into saturation when primary short circuit current is present at the CT.
14. Interface data with monitoring or control network.
15. Wiring Diagrams: For each switchgear assembly include the following:
    a. Power, signal, and control wiring.
    b. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
    c. Schematic control diagrams.
    d. Diagrams showing connections of component devices and equipment.
    e. Schematic diagrams showing connections to remote devices including connection details to the communications network.
16. B. Where applicable, the following additional information shall be submitted to the Engineer:
    a. Busway connection
    b. Connection details between close-coupled assemblies
    c. Composite floor plan of close-coupled assemblies
    d. Key interlock scheme drawing and sequence of operations
    e. Descriptive bulletins

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where piping and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Identify field measurements.

D. Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals. In addition to items specified in

Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device.
3. Include safety Standard Operating Procedures (SOP), including de-energization and isolation procedures.

E. The following information shall be submitted for record purposes:

F. Final as-built drawings and information for items listed in Paragraph 1.04, and shall incorporate all changes made during the manufacturing process.

1. Wiring diagrams
2. Certified production test reports
3. Installation information including equipment anchorage provisions
4. Seismic certification as specified

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain switchgear and switchgear components through one source from a single manufacturer.

C. The switchgear and all their components of the types and sizes required shall have been satisfactorily manufactured and in satisfactory use for the purpose similar to those intended herein for no less than three years.

D. The manufacturer shall be ISO 9001 certified

E. Entities manufacturing metal-clad switchgear shall have experience on at least two projects involving complexities and utility requirements of a size and scope similar to those required under this contract and has successfully delivered, installed, and commissioned MV switchgear at these projects.

F. Conduct system short circuit calculations based on the utility parameters supplied by the Authority to ensure that the proposed switchgear ratings are compatible with tabulated results. Report shall be submitted for review and approval.

G. Conduct coordination study to tabulate the relay settings of all relays in the switchgear system. Report shall be submitted for Engineer's review and approval.

1.5 WARRANTY

A. Special Battery Warranties: Manufacturer and Installer agree to repair or replace the switchgear control system storage batteries that fail in materials or workmanship within specified warranty period.

B. Warranted Cycle Life for Premium VRLA Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

1. For discharge rate not faster than eight hours, discharge duration not longer than eight hours, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 40 discharge cycles.
2. For discharge rate not faster than 30 minutes, discharge duration not longer than 30 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 20 discharge cycles.
3. For discharge rate not faster than 15 minutes, discharge duration not longer than 1.5 minutes, and voltage at end of discharge not less than 1.67 V, warranted life must be not fewer than 750 discharge cycles.

1.6 FACTORY TESTING

A. The switchgear shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchgear shall be tested to assure the accuracy of the wiring, and the functioning of all the equipment.

B. Assemble switchgear and equipment in manufacturer's plant and perform the following:

1. Functional tests of all relays, instruments, meters, and control devices by application of secondary three-phase voltage to voltage circuits and injection of current in current transformer secondary circuits.
2. Functional test of all control and trip circuits. Connect test devices into circuits to simulate operation of controlled remote equipment such as circuit-breaker trip coils, close coils, and auxiliary contacts. Test proper operation of relay targets.
3. Prepare equipment for shipment.
4. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.
5. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

C. Perform production tests on each circuit breaker housing for this Project, complying with IEEE ANSI C37.09.

1. Perform mechanical operation tests to ensure proper functioning of shutters, operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.

2. Conduct an alignment test with master circuit breaker to verify all interfaces.
3. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.
4. Perform the control wiring dielectric test at 1500 V for one minute.
5. Perform the dielectric test on primary and secondary circuits.

D. Perform production tests, on each circuit breaker supplied for this Project, complying with IEEE ANSI C37.09.

1. Perform mechanical operation tests to ensure proper functioning of the switch.
2. Conduct an alignment test with master cell to verify all interfaces and interchangeability.
3. Verify the contact gap. Perform terminal-to-terminal resistance test.
4. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence. Operate the circuit breakers over the range of minimum to maximum of the control voltage.
5. Perform the control wiring dielectric test at 1500 V for one minute.
6. Set the contact gap.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver in sections of lengths that can be moved past obstructions in delivery path as indicated.

B. Load break switches and fault interrupters shall be shipped preassembled at the factory. No field assembly shall be required.

C. Installing contractor shall store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

D. If stored in areas subjected to weather, installing contractor shall cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

E. All equipment and materials shall be suitably wrapped, crated, boxed or otherwise prepared for shipment to prevent damage during handling and shipping. All openings shall be properly protected to prevent the entrance of any water dirt or debris. All parts not constructed to be normally exposed to the weather shall be suitably weatherproofed.

F. Each box or crate shall be equipped with suitable lifting devices to facilitate unloading and shall contain a detailed packing list.

G. Packaging shall be labeled and numbered so that each section or assembly may be identified before being uncrated. Any items not fully assembled to the switchgear

structure shall be packaged separately. Removable circuit breaker units shall be packaged and shipped separately.

H. Where switchgear sections must be separated for shipment, all information, materials, and equipment to facilitate reassembly and reconnection of interconnecting bus work and wiring in the field shall be furnished.

I. The Contractor shall outline measures he shall take with respect to storage and preventive maintenance requirements following delivery of the switchgear to the construction site.

J. Adequate means shall be provided for lifting by fork lifts and cranes and for moving the equipment on rollers. Lift points shall be marked on each crate.

K. Indoor switchgear that cannot be installed immediately shall be stored in a dry, clean location within a heated building. Where no heating is available suitable temporary power shall be provided to each section of switchgear to activate the cubicle heaters. During storage, the switchgear shall be placed on a level surface.

1.8 COORDINATION

A. Coordinate layout and installation of switchgear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

B. Installing contractor shall coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section “Cast-in-Place Concrete.”

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Six of each type and rating used. Include spares for future transformers, control power circuits, and fusible devices.
2. Indicating Lights: Six of each type installed.
3. Touchup Paint: Three containers of paint matching enclosure finish, each 250 mL.
4. Primary Switch Contact Lubricant: two container(s).

B. Maintenance Tools: Furnish tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include the following:

1. Fuse-handling tool.
2. Extension rails, lifting device, transport or dockable dolly or mobile lift, and all other

items necessary to remove circuit breaker from housing and transport to remote location.

3. Racking handle to move circuit breaker manually between connected and disconnected positions, and a secondary test coupler to permit testing of circuit breaker without removal from switchgear.

PART 2 PRODUCTS

2.1 DESCRIPTION

A. The switch shall consist of manually operated, load interrupting, SF6 insulated, 630A linear puffer switch and a manually operated, electronically controlled fault interrupter. The switch shall be designated G&W VPNI style.

2.2 QUALITY ASSURANCE

A. Manufacturer Qualifications: The chosen manufacturer shall have at least 30 years experience in manufacturing SF6 insulated medium voltage switchgear. The manufacturer of the switches shall be completely and solely responsible for the performance of the load break switch and fault interrupter as well as the complete integrated assembly as rated.

B. The manufacturer shall furnish certification of ratings of the load break switch, fault interrupter and the integrated switch assembly upon request.

C. The switch shall comply with requirements of the latest revisions of applicable industry standards, including:

IEEE C37.71, IEEE C37.74, IEEE C37.60, IEEE 386

D. The switch manufacturer shall be ISO 9001:2008 and ISO 14001:2004 certified.

2.3 SWITCH CONFIGURATION

A. The switch shall be equipped with two 3-phase load break switch ways and two 3-phase fault interrupter ways.

B. The switch shall be designed for front access to cables and operators.

C. Switch shall be manufactured by G&W, part no. VPNI42-376-25-11F.

2.4 SWITCH CONSTRUCTION

A. General

1. Switch contacts and cable entrance terminations shall be contained in a single welded mild steel tank with entrances internally connected by copper conductors. Construction shall be a dead front design.
2. Switches shall be shipped factory filled with SF6 gas conforming to ASTM D-2472. Switch tanks shall be painted ASA70 light gray using a corrosion-resistant epoxy paint.

B. Load Break Switch

1. Each switching way is to be equipped with an internally mounted operating mechanism capable of providing quick-make, quick-break operation in either switching direction.
2. The mechanism must be capable of delivering sufficient torque and shall be provided with latches for each position to assure load interrupting, fault closing and momentary ratings.
3. All switch positions are to be clearly identified and be padlockable. The operating mechanism shall be actuated from outside the switch tank with an operating handle. The operating shaft shall be made of stainless steel for maximum corrosion resistance.
4. A double “O” ring type operating shaft seal shall be used for a leak resistant, long life seal. Switch contacts shall be a tulip-bayonet design and made of plated, high-conductivity copper alloy with arcing tips of copper/tungsten alloy to assure permanent low resistance and to avoid sticking during operations. The contacts shall be designed such that arcing does not occur in the area of main current interchange and contact pressure will increase with increased current flow.
5. The stationary contacts shall be supported independent of the cable entrance bushings, eliminating possible misalignment.
6. The contact nozzle shall have a converging/diverging geometry which improves the flow of SF6 into the arc zone.
7. Contact travel shall be a minimum of 3 inches and have sufficient open contact separation to assure efficient arc extinction and to withstand field DC testing levels and maintain BIL levels.
8. Switch contacts shall be clearly visible in the open position through viewing windows. Auxiliary blades used for load interruption are not acceptable.

C. Fault Interrupters

1. The fault interrupter shall consist of vacuum bottles and a spring-assisted operating mechanism. The mechanism used shall be designated "Model NI" for three phase operation.
2. The mechanism shall consist of three vacuum bottles mechanically linked to a single spring-assisted operating mechanism. The fault interrupter operating mechanism shall consist of the support assembly, linkage, spring latch mechanism, and solenoid utilized for electronic tripping.
3. Maximum interrupting time shall be three cycles (50 msec). The movable contact shaft shall be flagged to indicate the contact position, open or closed. This contact position indicator shall be fully visible through viewing windows supplied in the

switch tank.

4. Each tap phase is to be equipped with an individual 630A vacuum interrupter fully enclosed in an SF6 insulated switch tank. Electrical opening shall be by a solenoid that is activated from sources external to the switch tank.
5. Manual reset or closing of the fault interrupter shall be mechanical with the use of an external operating handle.
6. The mechanical linkage assembly shall provide for a "trip-free" operation which allows the fault interrupter to interrupt independent of the operating handle. The fault interrupter shall include a three position load break switch in series with the fault interrupter to provide a visible break of the circuit.

2.5 DESIGN RATINGS

A. Switch Ratings - the switch shall be rated:

SELECTION OF RATINGS	IEEE/IEC		
Maximum design voltage	15.5 kV		
Voltage class	15 kV		
Impulse level (BIL)	110 kV		
One minute withstand	35 AC kV		
One minute withstand, production test rating	34 AC kV		
15 minute withstand	53 DC kV		
Continuous and load break current	630 Amps		
Load Break Switch Momentary current	40 kA asym		
Load Break Switch Fault close current, (3 times)	40 kA asym		
Load Break Switch One second current	25 kA sym		
Fault Interrupter Symmetrical interrupting rating	25kA		
Load Break Switch Open gap withstand	200 kV		
Load Break Switch 10 operation overload interrupting capability	3000 Amps		
Load Break Switch Operations load interrupting endurance at 600A	1200		

Mechanical endurance, operations	2000		

B. Interrupters shall be tested IEEE C37.60 Fault Interrupting Duty per the table below

Percent of Maximum: Interrupting Rating	Approx. Interrupting: Current Amps	No. of Fault: Interruptions
15-20%	2000	44
45-55%	6000	56
90-100%	12000	16

2.6 CABLE ENTRANCES

A. Load Break Switches

1. Cable entrances shall be tested to IEEE 386 and be 600 amp G&W Quik-Change disconnectable apparatus bushing, bottom mount.

B. Fault Interrupters

1. Cable entrances shall be tested to IEEE 386 and be 600 amp G&W Quik-Change disconnectable apparatus bushing, bottom mount.

2.7 ELECTRONIC CONTROL

A. An electronic control shall be provided to monitor load and fault current on all three phases of the fault interrupters. Each phase shall have a current transformer (max 500:1) mounted inside the switch tank to provide control power and current sensing. No external power source shall be required for overcurrent protection. Operational temperature range of the control shall be -40°C to +65°C. Maximum time for power up and ready-to-trip when closing on a circuit shall be ten percent of the trip time or 1/2 cycle, whichever is greater. Trip selection may be made with the fault interrupter energized. The range of Phase Overcurrent minimum trip settings shall be 15-300A (500:1 CT).

B. Type 4 Plus

1. The control shall include 30 Time Current Characteristic (TCC) curve. All settings shall be inputted via a computer. The control shall allow for multiple TCC curve modification options, including Instantaneous Trip, Inrush Restraint, and Phase Time Delay. In addition, the control shall include a Phase Imbalance (Ground Fault) setting. The control shall allow for the selection of independent TCC curves for Phase Overcurrent and Phase Imbalance (Ground Fault). The control shall include a Sequence of Events Recorder (SER) which shall record the last 16 causes of trip. The control programming software shall include password protection, the ability to download the SER, and the ability to save and print setting files.
2. Options for Electronic Controls
   a. The control shall include an option to allow it to be powered via a 120VAC source. The control shall include an option to accept a dry contact input that will cause it to initiate a trip signal to the interrupter.
   b. For Dry Applications: Control mounted in a NEMA4X rated fiberglass enclosure

PART 3 EXECUTION

3.1 EXAMINATION

A. Upon delivery of switchgear and prior to unloading, inspect equipment for damage.

1. Examine tie rods and chains to verify they are undamaged and tight and that blocking and bracing are tight.
2. Verify that there is no evidence of load shifting in transit and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Examine switchgear for external damage, including dents or scratches in doors and sill, and termination provisions.
4. Compare switchgear and accessories received with the bill of materials to verify that the shipment is complete. Verify that switchgear and accessories conform to the manufacturer's quotation and shop drawings. If the shipment is not complete or does not comply with project requirements, notify the manufacturer in writing immediately.
5. Unload switchgear, observing packing label warnings and handling instructions.
6. Open compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle switchgear in accordance with manufacturer's recommendations, avoid damage to the enclosure, termination compartments, base, frame, tank, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.
2. Protect switchgear compartments against the entrance of dust, rain, and snow.
3. Transport switchgear upright to avoid internal stresses on equipment mounting assemblies. Do not tilt or tip switchgear.
4. Use spreaders or a lifting beam to obtain a vertical lift and to protect switchgear from straps bearing against the enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
5. Do not damage structure when handling switchgear.

C. Storage:

1. Store switchgear in a location that is clean and protected from weather. Protect

switchgear from dirt, water, contamination, and physical damage. Do not store switchgear in the presence of corrosive or explosive gases.
2. Store switchgear with compartment doors closed.
3. Regularly inspect switchgear while in storage and maintain documentation of storage conditions, noting any discrepancies or adverse conditions.
4. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

D. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.

E. Pre-Installation Checks:

1. Verify removal of any shipping bracing after placement.
2. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at switchgear location.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with the provisions of IEEE ANSI C37.20.2 subclause titled "Guide for Handling, Storage, and Installation."

B. Anchor switchgear assembly to 100-mm (4-inch), channel-iron sill embedded in floor or concrete base and attach by bolting.

1. Sills: Select to suit switchgear; level and grout flush into floor or concrete base.
2. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration and Seismic Controls for Electrical Systems" for seismic-restraint requirements.
3. Concrete Bases: 100-mm (4-inch), reinforced, with chamfered edges. Extend base no less than 75 mm (3 inches) in all directions beyond the maximum dimensions of switchgear, unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Switchgear shall be installed level and plumb. Switchgear shall tilt less than 1.5 degrees while energized.

D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's written instructions and NFPA 70.

E. Comply with NECA 1.

F. Comply with NECA 430.

3.3 IDENTIFICATION

A. Diagram and Instructions:

1. Frame under clear acrylic plastic on front of switchgear.
   a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
   b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

3.4 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Grounding Connections at Interior Locations:

1. Install bare copper cable 350 MCM from each end of the switchgear ground pad to the substation ground bar.
2. Bond surge arrester to the switchgear ground pad and then to the substation ground bar with bare copper conductors, sized per manufacturers recommendations.
3. Keep leads as short as practicable with no kinks or sharp bends.
4. Make joints in grounding conductors and loops by exothermic weld or compression connector.

C. Grounding at Exterior Locations:

1. Install tinned bare copper cable not smaller than No. 4/0 AWG, for counterpoise buried not less than 30 inches (765 mm) below grade interconnecting the grounding electrodes.
2. Bond surge arrester to the switchgear enclosure and then to the grounding electrode system with bare copper conductors, per manufacturers recommendations.
3. Keep lead lengths as short as practicable with no kinks or sharp bends.
4. Fence and equipment connections shall not be smaller than No. 4 AWG.
5. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm).
6. Bond each gate section to the fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
7. Make joints in grounding conductors and loops by exothermic weld or compression connector.

D. Cable terminations at switchgear are specified in Division 26 Section "Medium-Voltage Cables."

E. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values.

F. Terminate grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate the number of conductors for termination.

G. Complete switchgear grounding and lightning arrester connections prior to making any other electrical connections.

H. On completion of installation, inspect interior and exterior of switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

3.5 SIGNS AND LABELS

A. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

C. Hazard Alerting Signs

1. Each unit of switchgear shall be provided with a “Danger--Hazardous Voltage--Failure to Follow These Instructions Will Likely Cause Shock, Burns, or Death” sign. Each unit of switchgear shall be provided with a “Danger--Keep Away--Hazardous Voltage--Will Shock, Burn, or Cause Death” sign.

D. Nameplates, Ratings Labels, and Connection Diagrams

1. Each unit of switchgear shall be provided with a nameplate indicating the manufacturer’s name, catalog number, model number, date of manufacture, and serial number. Each unit of switchgear shall be provided with a ratings label indicating the following: voltage rating; main bus continuous rating; short-circuit rating; fault interrupter ratings including interrupting and duty-cycle fault-closing; and load break switch ratings including duty-cycle fault-closing and short-time.

3.6 FACTORY PRODUCTION TESTS

A. Each switch shall undergo the following production testing. Test reports must be available upon request

1. Each switch shall be factory filled with SF6 gas. The gas shall be checked for moisture content
2. Each switch shall undergo an SF6 leak check to verify the integrity of the tank, seals, and gaskets
3. A mechanical operation check of each switching mechanism
4. AC hi-pot tested one minute phase-to-phase, phase-to-ground and across the open contacts
5. Circuit resistance shall be checked.
6. Primary current injection test to test CTs, trip mechanism, and electronic control

3.7 STANDARD COMPONENTS

A. The following shall be included as standard:

1. Mild steel tank
2. Fixed operating handles for the load break switches and one (1) removable handle to operate the fault interrupters.
3. Gas pressure gauge and fill valve.
4. ½-13 nuts to provide sufficient grounding provisions for all cable entrances
5. Stainless steel three line diagram and corrosion-resistant nameplates.
6. Switch operating handles with padlock provision.
7. Parking stands for each bushing
8. (1) viewing window per load break switch to view open contact position
9. (1) viewing window per fault interrupter to view vacuum bottle position

3.8 OPTIONS

A. The following options shall be supplied:

1. Quick disconnect fitting to remove the pressure gauge without loss of SF6 gas
2. 4/0 brass ground lug
3. Junction box for wiring external power source for Electronic Control, NEMA 4X

3.9 FIELD QUALITY CONTROL

A. Field tests must be witnessed by Commissioning agent per Division 1.

B. Administrant for Tests and Inspections:

1. Engage qualified testing agency to administer and perform tests and inspections.
2. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

C. Prepare for acceptance tests as follows:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods."
2. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.

D. Medium-Voltage Switchgear Assembly Field Tests NETA ATS, Section 7.1 :

1. Visual and Mechanical Inspection:

a. Verify that fuse and circuit breaker sizes and types correspond to Drawings and coordination study, as well as to the circuit breaker's address in the control network.
b. Verify that current and voltage transformer ratios correspond to Drawings.
c. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
d. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

    1). Attempt closure on locked-open devices. Attempt to open locked-closed devices.

    2). Make key exchange with devices operated in off-normal positions.

e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
f. Inspect insulators for evidence of physical damage or contaminated surfaces.
g. Verify correct barrier and shutter installation and operation.
h. Exercise active components.
i. Inspect mechanical indicating devices for correct operation.
j. j. Verify that filters are in place and vents are clear.
k. Perform visual and mechanical inspection of instrument transformers in accordance with "Instrument Transformer Field Tests" Paragraph.
l. Inspect control power transformers.

    1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
    2) Verify that primary and secondary fuse or circuit breaker ratings match drawings.
    3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

    a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Perform dc voltage insulation-resistance tests on each bus section, phase to phase and phase to ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

        1) Insulation-resistance values of bus insulation shall be in accordance with manufacturer's published data. In the absence of

manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.

2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

c. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted in accordance with NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 V dc for 300-volt rated cable and 1000 V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring shall not be less than two megohms.

e. Control Power Transformers:

1) Perform insulation-resistance tests. Perform measurements from winding to winding and each winding to ground. Insulation-resistance values of winding insulation shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.
3) Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
4) Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

f. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

g. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

h. Perform system function tests in accordance with "System Function Tests" Article.
i. Verify operation of space heaters.
j. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

E. Ground Resistance Test:

1. Visual and Mechanical Inspection:

a. Verify ground system complies with Contract Documents and NFPA 70 Article 250, "Grounding and Bonding."
b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections shall be free of corrosion.
c. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
d. Inspect anchorage.

2. Electrical Tests:

a. Perform fall-of-potential or alternative test in accordance with IEEE Std 81 on the main grounding electrode or system. The resistance between the main grounding electrode and ground shall be no more than 5 ohms.
b. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohm. Compare equipment nameplate data with Contract Documents.
c. Inspect physical and mechanical condition.
d. Inspect bolted electrical connections for high resistance using a low resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

3. Ground-Fault Systems: Perform tests and inspections stated in NETA ATS, Section 7.14

F. Metering Devices Field Tests NETA ATS, Section 7.11:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS,

Table 100.12. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

c. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
d. Verify the unit is clean.
e. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Verify accuracy of meters at all cardinal points. Meter accuracy shall be in accordance with manufacturer's published data.
c. Calibrate meters in accordance with manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.
d. Verify all instrument multipliers. Instrument multipliers shall be in accordance with system design specifications.
e. Verify that current transformer and voltage transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

G. Microprocessor-Based Protective Relay Field Tests NETA ATS, Section 7.9:

1. Visual and Mechanical Inspection:

a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of light-emitting diodes, display, and targets.
c. Record passwords for each access level.
d. Clean the front panel and remove foreign material from the case.
e. Check tightness of connections.
f. Verify that the frame is grounded in accordance with manufacturer's instructions.
g. Set the relay in accordance with results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to the grounded frame in accordance with manufacturer's published data.
b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.
c. Functional Operation: Check functional operation of each element used in the protection scheme as follows:

1) Timing Relay:

a) Determine time delay.
b) Verify operation of instantaneous contacts.

2) Instantaneous Overcurrent Relay:

a) Determine pickup.
b) Determine dropout.
c) Determine time delay.

3) Time Overcurrent:

a) Determine minimum pickup.
b) Determine time delay at two points on the time current curve.

4) Ground Detector Relay:

a) Determine maximum impedance to ground causing relay pickup.

d. Control Verification:

1) Functional Tests:

a) Check operation of all active digital inputs.
b) Check output contacts or silicone-controlled rectifiers (SCRs), preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
c) Check internal logic functions used in protection scheme.
d) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

H. DC System Vented NiCd Batteries Field Test:

3. Visual and Mechanical Inspection:

a. Verify that batteries are adequately located.
b. Verify that battery area ventilation system is operable.
c. Verify existence of suitable eyewash equipment.
d. Verify equipment nameplate data complies with Contract Documents.
e. Inspect physical and mechanical condition.
f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
g. Verify electrolyte level. Measure pilot-cell electrolyte temperature, and correct as recommended by manufacturer's maintenance procedures to bring the temperature and electrolyte level to within normal limits.

h. Verify the units are clean.
i. Inspect spill containment installation.
j. Verify application of an oxide inhibitor on battery terminal connections.

4. Electrical Tests:

a. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.
b. Verify charger functions and that alarms comply with system manufacturer's recommendations.
c. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation. Cell voltages shall be within 0.05 volt of each other or in accordance with manufacturer's published data.
d. Measure intercell connection resistances.
e. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state.
f. Perform a load test in accordance with manufacturer's published data or IEEE Std 1106. Replace units that fail to pass the test.
g. Measure the battery system voltage from positive to ground and negative to ground. Voltage measured from positive-to-ground shall be equal in magnitude to the voltage measured from negative to ground.

I. Nonconforming Work:

5. Switchgear will be considered defective if it does not pass tests and inspections.
6. Remove and replace defective units and retest.

J. Prepare test and inspection reports. Record as-left set points of adjustable devices.

3.10 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

3.11 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, but not more than six months after Final Acceptance, if requested by Owner, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days

of three-phase voltage recording at the outgoing section of each switchgear. Use voltmeters with calibration traceable to NIST standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.

2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

    a. Adjust switchgear taps.
    b. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action has been performed, until specified results are obtained.
4. Report:

    a. Prepare a written report covering monitoring performed and corrective action taken.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain medium-voltage switchgear.

B. The manufacturer shall provide an eight (8) hour "hands-on" training course for the customer's operating personnel which shall cover the following topics:

1. Overall system description and theory of operation.
2. Automatic operation.
3. Manual operation.
4. Safeties and protective relaying.
5. Recommended system check lists and log sheets.
6. Recommended preventive maintenance.
7. Instruction on the operation of the assembly, circuit breakers, and major components within the assembly.

End of Section

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Section 26 24 13

SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Metering
5. Control power.
6. Accessory components and features.
7. Identification.

B. Related Requirements

1. Section 260573 "Overcurrent Protective Device Coordination Study and Arc-Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.

    a. Selective Coordination and Arc Flash Hazard Analysis shall be completed by the equipment manufacturer prior to the release of submittals.

1.3 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.

4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
9. Include schematic and wiring diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Routine maintenance requirements for switchboards and all installed components.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.

2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) if required due to site/installation environmental conditions to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.9 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place as required.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary, or permanent HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).

b. Altitude: Not exceeding 6600 feet (2000 m).

1.10 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Schneider Electric USA (Square D).
2. General Electric
3. Eaton

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually, and Drawout mounted as shown on drawings.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

I. Nominal System Voltage: As shown on drawings.

J. Main-Bus Continuous: As shown on drawings.

K. Indoor Enclosures: Steel, NEMA 250, Type 1.

L. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

M. Barriers: Between adjacent switchboard sections.

N. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

O. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

P. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

Q. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

R. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
3. Copper feeder circuit-breaker line connections.

4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
5. Ground Bus: 1/4-by-2-inch- (6-by-50-mm-) hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
6. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
7. Disconnect Links:

    a. Isolate neutral bus from incoming neutral conductors.
    b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
8. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
9. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

S. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

T. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

U. Manufacturers: Provided by manufacturer of switchgear and factory installed as part of the distribution equipment. Installation shall minimize lead length. Provide SPD for all switchboards as indicated on schedules.

2.2 SURGE SUPPRESSION DEVICES

A. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, wired-in, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL 1449, third edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:

1. Fuses, rated at 200-kA interrupting capacity.
2. Fabrication using bolted compression lugs for internal wiring.
3. Redundant suppression circuits.
4. Redundant replaceable modules.
5. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
6. LED indicator lights for power and protection status.
7. Audible alarm, with silencing switch, to indicate when protection has failed.
8. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
9. Six-digit, transient-event counter set to totalize transient surges.

B. Peak Single-Impulse Surge Current Rating: 80 kA per mode/160 kA per phase.

C. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

A. Protection modes and UL 1449 SVR for grounded wye circuits with 208Y/120-V, three-phase, four-wire circuits shall be as follows:

1. Line to Neutral: 400 V for 208Y/120.
2. Line to Ground: 400 V for 208Y/120.
3. Neutral to Ground: 400 V for 208Y/120.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents. With the following accessories as indicated on the drawings.
1. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

a. Instantaneous trip.
b. Long- and short-time pickup levels.
c. Long and short time adjustments.
d. Ground-fault pickup level, time delay, and I squared t response.

2. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
f. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
i. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
k. Power measurement: Integral with electronic trip unit;

1) digital anmeter
2) power and energy measurement
3) power quality measurements
4) current demand and power demand measurements

l. Firmware and Gateways: Meters shall be provided with all required Firmware and Gateways to allow for remote connection for the BAS system to collect all meter data as required for LEED reporting needs via BACnet IP protocol. Meter shall also allow remote connection for user download of all recorded meter data. All meter data shall be available for remote download.

m. Metering display accuracy of the complete system, including current sensors, auxiliary CTs and the trip unit, shall be +/- 1% of full scale for current values. Metering display accuracy of the complete system shall be +/- 2% of full scale for power and energy values.

n. The unit shall be capable of monitoring the following data:
1) Instantaneous value of phase, neutral and ground current
2) Instantaneous value of line-to-line voltage
3) Minimum and maximum current values
4) Watts, Vars, VA, watthours, Varhours and VA hours
5) The energy-monitoring parameter values (peak demand, present demand, and energy consumption) shall be indicated in the trip unit's alphanumeric display panel.
6) The trip unit shall initiate a waveform capture at a selectable interval and automatically capture events resulting in Long Time, Short Time, Instantaneous, and GF trip. Programming may be done via a keypad at the faceplate of the unit or via the communication network.

B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current where shown on the drawing as a Drawout Circuit Breaker.

1. Drawout circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings as shown on drawings:

a. Instantaneous trip.
b. Time adjustments for long- and short-time pickup.
c. Ground-fault pickup level, time delay, and I squared t response.
d. Ground Fault Alarm.

4. Remote trip indication and control.
5. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
6. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
7. Control Voltage: 120-V ac.
8. Power measurement: Integral with electronic trip unit;
1) digital anmeter
2) power and energy measurement

3) power quality measurements
4) current demand and power demand measurements

9. Firmware and Gateways: Meters shall be provided with all required Firmware and Gateways to allow for remote connection for the BAS system to collect all meter data as required for LEED reporting needs via BACnet IP protocol. Meter shall also allow remote connection for user download of all recorded meter data. All meter data shall be available for remote download.
10. Metering display accuracy of the complete system, including current sensors, auxiliary CTs and the trip unit, shall be +/- 1% of full scale for current values. Metering display accuracy of the complete system shall be +/- 2% of full scale for power and energy values.
11. The unit shall be capable of monitoring the following data:
    1) Instantaneous value of phase, neutral and ground current
    2) Instantaneous value of line-to-line voltage
    3) Minimum and maximum current values
    4) Watts, Vars, VA, watthours, Varhours and VA hours
    5) The energy-monitoring parameter values (peak demand, present demand, and energy consumption) shall be indicated in the trip unit's alphanumeric display panel.
    6) The trip unit shall initiate a waveform capture at a selectable interval and automatically capture events resulting in Long Time, Short Time, Instantaneous, and GF trip. Programming may be done via a keypad at the faceplate of the unit or via the communication network.

2.4 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Electrically Interlocked Main and Tie Circuit Breakers (if shown on drawings): Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

D. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.6 IDENTIFICATION

A. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

B. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
3. Protect from moisture, dust, dirt, and debris during storage and installation.
4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches (50-mm) above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

G. Install spare-fuse cabinet.

H. Comply with NECA 1.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." If required.

B. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

C. Support and secure conductors within the switchboard according to NFPA 70.

D. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Acceptance Testing:

    a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
    b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Perform the following infrared scan tests and inspections, and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear panels (as applicable) so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Switchboard will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

End of Section

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PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, and Section 260500 Common Work Results for Electrical apply to this Section.

B. Related Requirements

1. Section 260573 "Overcurrent Protective Device Coordination Study and Arc-Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.

a. Selective Coordination and Arc Flash Hazard Analysis shall be completed by the equipment manufacturer prior to the release of submittals.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Key interlock scheme drawing and sequence of operations.
10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI, AFCI and GFEP: Two spares for each panelboard if used on the project.
3. Panel directories: 10% of project directories provided as blanks

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or ISO 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407/NEMA PB 1.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
    b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than seven business days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Flush and Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Kitchen and Wash-Down Areas: NEMA 250, Type 4X stainless steel
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

2. Height: 84 inches (2.13 m) maximum.
3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
4. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
5. Finishes:

a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: Steel, galvanized where construction sequencing exposes the back box to water, otherwise same finish as panels and trim.

G. Incoming Mains:

1. Location: Top or bottom, as determined by contractor in conjunction with information presented on the drawings
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

a. Plating shall run entire length of bus.
b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
5. Split Bus: Vertical buses divided into individual vertical sections.

I. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.

J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 MANUFACTURER

A. Manufacturers: Subject to compliance with requirements, provide products or comparable product by one of the following:
   1. Schneider Electric – Square D
   2. General Electric
   3. Eaton

2.3 POWER PANELBOARDS

A. Panelboards: NEMA PB 1, distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

   1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

C. Mains: Refer to electrical panel schedules

D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers or Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers or Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Refer to electrical panel schedules.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Buses:

   1. Copper phase and neutral buses; 1~~2~~00 percent capacity neutral bus and lugs.
   2. Copper equipment and isolated ground buses.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Overcurrent Protective Devices shall be the same manufacturers as panelboard.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:

a. RMS sensing.
b. Field-replaceable rating plug or electronic trip.
c. Digital display of settings, trip targets, and indicated metering displays.
d. Multi-button keypad to access programmable functions and monitored data.
e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
f. Integral test jack for connection to portable test set or laptop computer.
g. Field-Adjustable Settings:

1) Instantaneous trip.
2) Long- and short-time pickup levels.
3) Long and short time adjustments.
4) Ground-fault pickup level, time delay, and I squared T response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Subfeed Circuit Breakers: Vertically mounted.
9. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Breaker handle indicates tripped status.
c. UL listed for reverse connection without restrictive line or load ratings.
d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.

f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
i. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
j. Auxiliary Contacts: SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
k. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
l. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
m. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
n. Multipole units enclosed in a single housing with a single handle.
o. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
p. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."
2. Fused Switch Features and Accessories:

a. Standard ampere ratings and number of poles.
b. Mechanical cover interlock with a manual interlock override, to prevent the opening of the cover when the switch is in the on position. The interlock shall prevent the switch from being turned on with the cover open. The operating handle shall have lock-off means with provisions for three padlocks.
c. Auxiliary Contacts: One normally open and normally closed contact(s) that operate with switch handle operation.

2.6 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2. Circuit directory shall include Pane ID, voltage rating and current rating of the panel, as well as identify the type and location of every load, all spares and available spaces.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407/NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407/NEMA PB 1.1.

D. Equipment Mounting:
   1. Attach panelboard to the vertical finished or structural surface behind the panelboard.

E. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

F. Mount panelboard cabinet plumb and rigid without distortion of box.

G. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

H. Install overcurrent protective devices and controllers not already factory installed.

   1. Set field-adjustable, circuit-breaker trip ranges.
   2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

I. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

J. Install filler plates in unused spaces.

K. Stub four 1-inch (25 mm) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (25 mm) empty conduits into raised floor space or below slab not on grade.

L. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

M. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:
1. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
2. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

End of Section

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WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Standard-grade receptacles, 125 V, 20 A.
2. GFCI receptacles, 125 V, 20 A.
3. Twist-locking receptacles.
4. Cord and plug sets.
5. Toggle switches, 120/277 V, 20 A.
6. Decorator-style devices, 20 A.
7. Occupancy sensors.
8. Wall plates.
9. Poke-through assemblies.

1.3 DEFINITIONS

A. AFCI: Arc-fault circuit interrupter.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

F. RFI: Radio-frequency interference.

G. SPD: Surge protective device.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Poke-Through, Fire-Rated Closure Plugs: One for every five floor service outlets installed, but no fewer than two.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

   1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
   2. Devices shall comply with requirements in this Section.

F. Devices for Owner-Furnished Equipment:

   1. Receptacles: Match plug configurations.
   2. Cord and Plug Sets: Match equipment requirements.

G. Device Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Essential Electrical System: Red.

H. Wall Plate Color: For plastic covers, match device color.

I. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 DECORATOR-STYLE DEVICES, 20 A

A. Decorator Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Wiring Devices - Arrow Hart).
    b. Leviton Manufacturing Co., Inc.
    c. Pass & Seymour; Legrand North America, LLC.
    d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Description: Two pole, three wire, and self-grounding. Square face.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498.

B. Decorator Tamper-Resistant Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Wiring Devices - Arrow Hart).
    b. Leviton Manufacturing Co., Inc.
    c. Pass & Seymour; Legrand North America, LLC.
    d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Decorator Single-Pole Switches, 120/277 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Wiring Devices - Arrow Hart).
    b. Leviton Manufacturing Co., Inc.

c. Pass & Seymour; Legrand North America, LLC.
d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

2. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
3. Standards: Comply with UL 20 and FS W-S-896.

2.3 DECORATOR STYPE GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Eaton (Wiring Devices - Arrow Hart).
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour; Legrand North America, LLC.
   d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Type: Feed and Non-feed through.
5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

B. Tamper-Resistant Duplex GFCI Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Pass & Seymour; Legrand North America, LLC.
   b. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.
2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Type: Feed and Non-feed through.
5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
6. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Tamper- and Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Eaton (Wiring Devices - Arrow Hart).
   b. Leviton Manufacturing Co., Inc.

c. Pass & Seymour; Legrand North America, LLC.
d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-15R.
4. Type: Feed and Non-feed through.
5. Standards: Comply with UL 498 and UL 943 Class A.
6. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.4 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Receptacles, voltage and amperage as indicated on drawings.:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Wiring Devices - Arrow Hart).
b. Leviton Manufacturing Co., Inc.
c. Pass & Seymour; Legrand North America, LLC.
d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

2. Configuration: NEMA WD 6, Configuration as indicated on drawings.
3. Standards: Comply with UL 498.

2.5 CORD AND PLUG SETS

A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.6 TOGGLE SWITCHES, 120/277 V, 20 A

A. Single-Pole Switches, 120/277 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Wiring Devices - Arrow Hart).
b. Leviton Manufacturing Co., Inc.

c. Pass & Seymour; Legrand North America, LLC.
d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

2. Standards: Comply with UL 20 and FS W-S-896.
3. Heavy-duty, specification grade

B. Three-Way Switches, 120/277 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Wiring Devices - Arrow Hart).
b. Leviton Manufacturing Co., Inc.
c. Pass & Seymour; Legrand North America, LLC.
d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

2. Comply with UL 20 and FS W-S-896.

C. Four-Way Switches, 120/277 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Wiring Devices - Arrow Hart).
b. Leviton Manufacturing Co., Inc.
c. Pass & Seymour; Legrand North America, LLC.
d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

2. Standards: Comply with UL 20 and FS W-S-896.

2.7 OCCUPANCY SENSORS

A. Wall Switch Sensor Light Switch, Dual Technology:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Wiring Devices - Arrow Hart).
b. Leviton Manufacturing Co., Inc.
c. Pass & Seymour; Legrand North America, LLC.
d. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

2. Description: Switchbox-mounted, combination lighting-control sensor and conventional switch lighting-control unit using dual (ultrasonic and passive infrared) technology.
3. Standards: Comply with UL 20.
4. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
5. Adjustable time delay of 20 minutes.

6. Able to be locked to Automatic and Manual-On mode.
7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux).
8. Connections: Provisions for connection to BAS.

2.8 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting.
3. Material for Laboratory Spaces: 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel with engraved nameplate with panel and circuit number feeding outlet.
4. Material for Unfinished Spaces: Galvanized steel.
5. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.9 POKE-THROUGH ASSEMBLIES

A. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pass & Seymour; Legrand North America, LLC.
2. Wiremold; Legrand North America, LLC.
3. Wiring Device-Kellems; Hubbell Incorporated, Commercial and Industrial.

C. Standards: Comply with scrub water exclusion requirements in UL 514.

D. Service-Outlet Assembly: Flush recessed type with devices as indicated on drawings.

E. Size: Selected to fit nominal 6-inch (150-mm) cored holes in floor and matched to floor thickness.

F. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.

G. Closure Plug: Arranged to close unused 6-inch (150-mm) cored openings and reestablish fire rating of floor.

H. Wiring Raceways and Compartments: Sized to accommodate services as indicated on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.

5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through GFCI receptacles unless protection of downstream receptacles is required because devices are not readily accessible, such as when behind refrigerators. Install feed-through (if multiple devices are on a single circuit) or blank (for dedicated circuits) GFCI receptacle device where receptacles are behind large equipment, such as refrigerators.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

C. Essential Electrical System: Mark receptacles supplied from the essential electrical system to allow easy identification using a self-adhesive label.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Perform the following tests and inspections:
   1. Test Instruments: Use instruments that comply with UL 1436.
   2. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Tests for Receptacles:

   1. Line Voltage: Acceptable range is 105 to 132 V.
   2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

D. Test straight-blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

E. Wiring device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

End of Section

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FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

    a. Control circuits.
    b. Motor-control centers.
    c. Panelboards.
    d. Switchboards.
    e. Enclosed controllers.
    f. Enclosed switches.

2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

    a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
    b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit

in electronic format suitable for use in coordination software and in PDF format.

5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in **Section 017700 "Closeout Procedures," Section 017823 "Operation and Maintenance Data,"** include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit **in electronic format suitable for use in coordination software and in PDF format**.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to **10** percent of quantity installed for each size and type, but no fewer than **three** of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than **40 deg F (5 deg C)** or more than **100 deg F (38 deg C)**, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
   1. Current limiting, 200,000 AIC minimum interrupting capacity, unless noted otherwise.
   2. Circuits 601-6000 amps: Class L
   3. Circuits 600 amps and less: Class RK1 or Class J
   4. Motor Circuits: Class RK5 dual element time delay or Class L (601-6000A)
   5. Transformer Primary Circuits: Class RK5

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

   1. Size: Adequate for storage of spare fuses specified with **15** percent spare capacity minimum.
   2. Finish: Gray, baked enamel.
   3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
   4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by **Owner**.

3.3 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

End of Section

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ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Molded-case switches.
7. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
5. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.
3. .

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.2 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB (Electrification Products Division)
2. Eaton.
3. Schneider Electric USA (Square D).

B. Type HD, Heavy Duty:

1. Single throw, unless otherwise indicated on drawings.
2. Three pole.
3. 600-V ac.
4. 1200 A and smaller.
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating -, coordinate with equipment/system to be served.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.
7. Service-Rated Switches: Labeled for use as service equipment.

2.3 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB (Electrification Products Division).
2. Eaton.
3. Schneider Electric USA (Square D).

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Three Pole, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating -coordinate with equipment/system to be served.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.
7. Service-Rated Switches: Labeled for use as service equipment.

2.4 RECEPTACLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB (Electrification Products Division).

2. Eaton.
3. Schneider Electric USA (Square D).

B. Type HD, Heavy-Duty, Three Pole, Single-Throw Nonfusible Switch: 600-V ac,amperage as indicated on drawings; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

C. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.

D. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

E. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating -coordinate with equipment/system to be served.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.
7. Service-Rated Switches: Labeled for use as service equipment.

2.5 SHUNT TRIP SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB (Electrification Products Division).
2. Eaton.
3. Schneider Electric USA (Square D).

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

C. Type HD, Heavy-Duty, Three Pole, Single-Throw Nonfusible Switch: 600-V ac,amperage as indicated on drawings; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, pilot, indicating and control devices.

E. Accessories:

1. Oiltight key switch for key-to-test function.
2. Oiltight red ON pilot light.
3. Isolated neutral lug; 200 percent rating.
4. For hydraulic elevators: Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
5. Form C alarm contacts that change state when switch is tripped.
6. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
7. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
8. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
9. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating -coordinate with equipment/system to be served.
10. Hookstick Handle: Allows use of a hookstick to operate the handle.
11. Lugs: Mechanical type, suitable for number, size, and conductor material.
12. Service-Rated Switches: Labeled for use as service equipment.

2.6 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB (Electrification Products Division).
2. Eaton.
3. Schneider Electric USA (Square D).

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated. Circuit breaker/circuit breaker combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations.

E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Lugs shall be suitable for 140 deg F (60 deg C) rated wire on 125-A circuit breakers and below 167 deg F (75 deg C) rated wire.

G. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 100 A to 400 A.

I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

J. Electronic Trip Circuit Breakers (required on 400A frame and larger): Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.

K. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

L. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

M. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Communication Capability: Circuit-breaker-mounted or Integral communication module with functions and features compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring and Control."
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
7. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.
8. Accessory Control Power Voltage: Integrally mounted, self-powered; 120-V ac.

2.7 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB (Electrification Products Division).
2. Eaton.
3. Schneider Electric USA (Square D).

B. Description: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

D. Features and Accessories:

1. Standard frame sizes and number of poles.
2. Lugs:
    a. Mechanical type, suitable for number, size, trip ratings, and conductor material.
    b. Lugs shall be suitable for 140 deg F (60 deg C) rated wire on 125-A circuit breakers and below 167 deg F (75 deg C) rated wire.
3. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.

2.8 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with:
1. NEMA 250 Type 1 - gray baked enamel paint, electrodeposited on cleaned, phosphatized steel
2. NEMA 250 Types 3R, 12 - gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel
3. NEMA 250 Type 4-4X stainless steel - a brush finish on Type 304 stainless steel .

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. For NEMA 250 Type 1, the circuit breaker operating handle shall be directly operable through the front cover of the enclosure. For NEMA 250 Type 3R, the circuit breaker operating handle shall be directly operable through the dead front trim of the enclosure.. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 PREPARATION

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect, Construction Manager, and Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.4 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

3.5 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and clearances.
c. Verify that the unit is clean.
d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
e. Verify that fuse sizes and types match the Specifications and Drawings.
f. Verify that each fuse has adequate mechanical support and contact integrity.
g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
i. Verify correct phase barrier installation.
j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

D. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify that the unit is clean.

e. Operate the circuit breaker to ensure smooth operation.
f. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.
h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
e. Determine the following by primary current injection:

1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.
h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.7 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Power Systems Study."

End of Section

Section 26 36 00

TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic Transfer Switches (ATS):

1.3 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

B. Coordinate transfer switch installation and control as specified in this section and Division 26 Section "Engine Generator Sets."

1.4 SUBMITTALS

A. General: Submit the following in accordance with Division 26 Section "Common Work Results for Electrical."

1. Final transfer switch approval subject to approved Division 26 Section "Protective Device Coordination Studies."

1.5 ACTION SUBMITTALS

A. Product Data: Submit wiring diagrams, manufacturers catalog sheets, and rating data including the following:

1. Transfer Switch Data:

a. Contactor manufacturer confirmation.
b. Catalog cut sheets.
c. Withstand and close-in ratings.
d. Material lists.
e. Complete control and power wiring diagrams.
f. Certified test results on identical switches.
g. Access requirements to isolation by-pass type switches.

B. Shop Drawings:

1. Layout Drawings: Provide room equipment layout drawings assuring proper clearances.
2. Single-Line Diagram: Show connections between transfer switch, power sources, and load.

3. Riser Diagram: Show interconnection wiring between transfer switches, and control panels.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data

1. Source Quality Control Test Reports:

a. Certified summary of prototype unit test report.
b. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
c. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
d. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
e. Report of sound generation.

2. Qualification Data For:

a. Installer.
b. Manufacturer.
c. Testing Agency.

B. Field Quality Control Test Reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays; provide relay setting and calibration instructions, including software, where applicable.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.

1.9 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Manufacturer: The transfer switches and all major items of auxiliary equipment shall be manufactured in the United States by manufacturers currently engaged in the production of such equipment. The equipment shall be standard factory produced units, factory assembled and tested and shipped to the job site by the engine generator assembler or his authorized dealer having a parts and service facility in the area.

2. Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Source Limitations: Obtain transfer switch equipment through one source from a single manufacturer.

C. Assembly Selection: The Drawings indicate sizes profiles, and dimensional requirements of engine generator sets and assembly equipment. Equipment having equal performance characteristics and complying with indicated maximum dimensions and profiles may be considered, provided deviations do not change the design concept intended performance, or code/future extension provision clearances. The burden of proof of equality is on the proposer a minimum of 10 days prior to bid.

D. Comply with ANSI/NETA ATS – Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems for field testing.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two (2) years or 1500 operating hours, whichever occurs first, from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Transfer Switch Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Russelectric, Inc.
2. ASCO

B. The emergency generator control system, associated batteries and battery chargers, and automatic transfer switches shall be supplied by the engine generator set manufacturer for unit responsibility.

C. Submit proof from the manufacturers of the engine generator set and transfer switches of qualified service capability, acceptable to the Engineer, in the area where the system will be installed.

2.2 REGULATORY REQUIREMENTS

A. Electrical components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with:
1. Comply with UL 1008 unless requirements of these Specifications are stricter.
2. CSA certified to CSA 22.2 No. 178 – 1978 Automatic Transfer Switches
3. IEC 60947-6-1 Low-voltage Switchgear and Controlgear; Multifunction equipment; Automatic Transfer Switching Equipment
4. NFPA 70 - National Electrical Code

5. NFPA 110 - Emergency and Standby Power Systems
6. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
7. NEMA Standard ICS10-1993 (formerly ICS2-447) - AC Automatic Transfer Switches
8. International Standards Organization ISO 9001:2008
9. UL508 Industrial Control Equipment
10. Comply with NEMA ICS 1.

2.3 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Automatic Transfer Switches shall be in accordance with specifications and as shown on the drawings.

C. The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a solenoid mechanism, momentarily energized. The transfer switch unit shall include both electrical and mechanical interlocks to prevent both sets of main contacts from being closed at the same time.

D. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 800 amps and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.

E. The switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.

F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

G. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008, rated to withstand the available RMS symmetrical short circuit current. Rating shall match or exceed the AIC rating of upstream circuit breakers serving transfer switch(es).

H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

K. Neutral Terminal: Solid and fully rated unless otherwise indicated.

L. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

M. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed tape or shrinkable sleeve markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via front access.

A. Enclosures: General-purpose NEMA 250, Indoor Dry and Clean Locations: Type 1, Outdoor Locations: NEMA 250, Type 3R/4X., Outdoor Locations Corrosive environment : NEMA 250, Type 4X., Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.4 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Switch Action: Double throw; mechanically held in both directions.
2. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.
3. Conductor Connectors: Suitable for use with conductor material and sizes.
4. Material: Hard-drawn copper, 98 percent conductivity.
5. Main and Neutral Lugs: Compression or Mechanical type.
6. Ground Lugs and Bus-Configured Terminators: Compression type.
7. Connectors shall be marked for conductor size and type according to UL 1008.

C. All bussing shall be copper and silver-plated. Aluminum bus and cable interconnections shall not be acceptable.

Close Transition Transfer Switch is added per client comment. Remove open transition transfer switch

D. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Source differential sensing shall be provided for the closed transition operating mode. The sensor shall enable transfer/re-transfer between live sources in the closed transition mode only when the two sources have a maximum voltage differential of 5%, frequency differential of 0.2 Hz and are within 5 electrical degrees. If the normal source becomes unacceptable, the controller shall automatically initiate an open transition (break before make) load transfer to the emergency source.
4. Closed transition transfer shall also be initiated when operating the transfer test selector switch. Retransfer to the normal source shall operate in closed transition mode at the conclusion of transfer test time delay.
5. Closed transition transfer shall be accomplished with no power interruption and without altering or actively controlling standby generator set.
6. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and source differential sensors confirming both sources are present and acceptable.

    a. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

    b. Initiation occurs without active control of generator.
    c. Automatic transfer-switch controller takes active control of generator to match frequency, phase angle, and voltage.
    d. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.

7. The transfer switch controls shall contain the following multiple levels of protection against extended parallel times in excess of 100ms by taking the following actions:
    a. If the Normal or Emergency main contacts both remain closed after a preset time delay, the controller shall attempt to return the transfer switch to “safe” state by removing paralleled condition.

        1) The controller shall open the last set of contacts that closed to remove the overlap condition.
        2) The controller is locked out from any further automatic operation.
        3) The “TS Locked Out” indicator (Red LED) is lit.
        4) The operation shall remain locked out until the “TS Locked Out” push –button is reset.

This is specifically added to per Cornell request.

b. Extend overlap protection relay that will provide a trip relay contact which operates in the event that the normal and emergency contacts remain overlapped for longer than 100 milliseconds.

c. If the main contacts still remain paralleled after the transfer switch controller action described in paragraph G. (1), a second independent extended parallel alarm timer will then operate an output relay with (2) form C contacts to alarm the extended overlap condition and/or shunt trip either the normal or emergency source breaker through a customer connected circuit to the breaker.

8. Failure of power source serving load initiates automatic break-before-make transfer.

9. Adjustable Time Delay:

a. An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting signals. Capability shall be provided to extend this time delay to 60 minutes by providing an external 24 VDC power supply.
b. A time delay shall be provided on transfer to emergency, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.
c. An adjustable time delay of 0 to 6 seconds to override momentary emergency source outage to delay all retransfer signals during initial loading of engine generator set.
d. Two-time delay modes (which are independently adjustable) shall be provided on re-transfer to normal. One-time delay shall be for actual normal power failures and the other for the test mode function. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.
e. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.
f. A time delay activated output signal shall also be provided to drive an external relay(s) for selective load disconnect control. The controller shall have the ability to activate an adjustable 0 to 5 minute time delay in any of the following modes:

1) Prior to transfer only.
2) Prior to and after transfer.
3) Normal to emergency only.
4) Emergency to normal only.
5) Normal to emergency and emergency to normal.
6) All transfer conditions or only when both sources are available.

g. The controller shall also include the following built-in time delays for Closed Transition Transfer with Bypass-Isolation operation:

1) 1 to 5 minute time delay on failure to synchronize normal and emergency sources prior to closed transition transfer.

2) 0.1 to 9.99 second time delay on an extended parallel condition of both power sources during closed transition operation.

h. All time delays shall be adjustable in 1 second increments, except the extended parallel time, which shall be adjustable in .01 second increments.

i. All time delays shall be adjustable by using the LCD display and keypad or with a remote device connected to the serial communications port. The time delay value displayed on the LCD or remote device shall be the remaining time until the next event occurs.

E. Electric Nonautomatic Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

F. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

G. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

H. Automatic Transfer-Switch Controller Features:

1. The controller's sensing and logic shall be provided by a single built-in microprocessor for maximum reliability, minimum maintenance, and the ability to communicate serially through an optional serial communication module.
2. A four-line, 20 character LCD display and keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through the serial communications input port. The following parameters shall only be adjustable via DIP switches on the controller:

   a. Nominal line voltage and frequency
   b. Single or three phase sensing
   c. Operating parameter protection
   d. Transfer operating mode configuration

3. A single controller shall provide twelve selectable nominal voltages for maximum application flexibility and minimal spare part requirements. Voltage sensing shall be true RMS type and shall be accurate to 1% of nominal voltage. Frequency sensing shall be accurate to 0.2%. The panel shall be capable of operating over a temperature range of -20 to +60 degrees C and storage from -55 to +85 degrees C.
4. The controller shall be capable (when activated by the keypad or through the serial port) of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or CBA).
5. Source status screens shall be provided for both normal and emergency to provide digital readout of voltage on all three phases, frequency and phase rotation.

6. The controller shall include a user selectable algorithm to prevent repeated transfer cycling to a source on an installation which experiences primary side, single phase failures on a Grounded Wye – Grounded Wye transformer which regenerates voltage when unloaded. The algorithm shall also inhibit retransfer to the normal (utility) source upon detection of a single phasing condition until a dedicated timer expires, the alternate source fails, or the normal source fails completely and is restored during this time delay period. The time delays associated with this feature shall be adjustable by the user through the controller keypad and LCD.
7. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance. Sensing and control logic shall be provided on multi-layer printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers. The panel shall be enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. The protective cover shall include a built-in pocket for storage of the operator's manuals.
8. Controller operates through a period of loss of control power.
9. Undervoltage Sensing for Each Phase of Normal and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
10. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
11. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
12. Test Switch: Simulate normal-source failure.
13. Switch-Position Pilot Lights: Indicate source to which load is connected.
14. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

15. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
16. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
17. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
18. Engine Shutdown Contacts:

    a. Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

19. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

20. Contact, rated 15 Amps 24 volts DC, to close on failure of normal source for to initiate engine starting.
21. Contact, rated 15 Amps 24 volts DC, to open on failure of normal source for customer functions.
22. Pilot lights shall be mounted on the cabinet door to indicate switch position. (Green in normal position; Red in emergency position; Amber in by-pass position)
23. Four auxiliary contacts rated 10 Amp, 120 volts AC (for switches 100 to 800 Amps) 15 Amp, 120 volts AC (for switches 1000 to 4000 amps), shall be mounted on the main shaft, two closed on normal, and two closed on emergency.
24. The ATS Control system shall incorporate modbus capability.

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7. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance. Sensing and control logic shall be provided on multi-layer printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers. The panel shall be enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. The protective cover shall include a built-in pocket for storage of the operator's manuals.
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9. Undervoltage Sensing for Each Phase of Normal and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
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11. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
12. Test Switch: Simulate normal-source failure.
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    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
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21. Contact, rated 15 Amps 24 volts DC, to open on failure of normal source for customer functions.
22. Pilot lights shall be mounted on the cabinet door to indicate switch position. (Green in normal position; Red in emergency position; Amber in by-pass position)
23. Four auxiliary contacts rated 10 Amp, 120 volts AC (for switches 100 to 800 Amps) 15 Amp, 120 volts AC (for switches 1000 to 4000 amps), shall be mounted on the main shaft, two closed on normal, and two closed on emergency.
24. The ATS Control system shall incorporate modbus capability.

2.5 TRANSFER SWITCH ACCESSORIES

A. A three-position momentary-type test switch shall be provided for the test / automatic / reset modes. The test position will simulate a normal source failure. The reset position shall bypass the time delays on either transfer to emergency or retransfer to normal. Switches which require utilizing the keypad and display function or have no manual time delay bypass means are not acceptable.

B. A SPDT contact, rated 5 amps at 30 VDC, shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

C. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of one contact, closed when the ATS is connected to the normal source and one contact closed, when the DTTS is connected to the emergency source.

D. Contact, rated 15 Amps 24 volts DC, to open on failure of normal source for customer functions.

E. Pilot lights shall be mounted on the cabinet door to indicate switch position. (Green in normal position; Red in emergency position; Amber in by-pass position).

F. LED indicating lights (16 mm industrial grade, type 12) shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal and emergency sources, as determined by the voltage sensing trip and reset settings for each source.

G. Four auxiliary contacts rated 10 Amp, 120 volts AC (for switches 100 to 800 Amps) 15 Amp, 120 volts AC (for switches 1000 to 4000 amps), shall be mounted on the main shaft, two closed on normal, and two closed on emergency.

H. Data Logging – The controller shall have the ability to log data and to maintain the last 99 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a non-volatile memory:

1. Event Logging

    a. Date and time and reason for transfer normal to emergency.
    b. Date and time and reason for transfer emergency to normal.
    c. Date and time and reason for engine start.
    d. Date and time engine stopped.
    e. Date and time emergency source available.
    f. Date and time emergency source not available.

2. Statistical Data
    a. Total number of transfers.
    b. Total number of transfers due to source failure.
    c. Total number of days controller is energized.
    Total number of hours both normal and emergency sources are available.

I. Communications Module – Shall provide remote interface module to support monitoring of vendor's transfer switch, controller and optional power meter. Module shall provide status, analog parameters, event logs, equipment settings & configurations over embedded webpage and open protocol. Features shall include:
1. Email notifications and SNMP traps of selectable events and alarms may be sent to a mobile device or PC.
2. Modbus TCP/IP, SNMP, HTTP, SMTP open protocols shall be simultaneously supported.
3. Web app interface requiring user credentials to monitor and control the transfer switch supporting modern smart phones, tablets and PC browsers. User will be able to view the dynamic one-line; ATS controls status, alarms, metering, event logging as well as settings.
4. Secure access shall be provided by requiring credentials for a minimum of 3 user privilege levels to the web app, monitor (view only), control (view and control)

and administrator (view, control and change settings). 128-Bit AES encryption standard shall be supported for all means of connectivity.

5. Shall allow for the initiating of transfers, retransfers, bypassing of active timers and the activating/deactivating of engine start signal shall be available over the embedded webpage and to the transfer switch vendor's monitoring equipment.
6. An event log displaying a minimum of ninety-nine (99) events shall be viewable and printable from the embedded webpages and accessible from supported open protocols.
7. Four (4) 100 Mbps Ethernet copper RJ-45 ports, five (5) serial ports, Termination dip-switches and LEDs for diagnostics.
8. DIN rail mountable.

J. System Status - The controller LCD display shall include a "System Status" screen which shall be readily accessible from any point in the menu by depressing the "ESC" key a maximum of two times. This screen shall display a clear description of the active operating sequence and switch position. For example,

Normal Failed
Load on Normal
TD Normal to Emerg
2min15s

K. External DC Power Supply – An optional provision shall be available to connect an external 24 VDC power supply to allow the LCD and the door mounted control indicators to remain functional when both power sources are dead.

L. Controllers that require multiple screens to determine system status or display "coded" system status messages, which must be explained by references in the operator's manual, are not permissible.

M. Self-Diagnostics - The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.

1. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

N. Remote Annunciator System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches.
3. Annunciation panel display shall include the following indicators:

    a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
    b. Switch position.
    c. Switch in test mode.
    d. Failure of communication link.

4. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

    a. Indicating Lights: Grouped for each transfer switch monitored.
    b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
    c. Mounting: Flush, modular, steel cabinet unless otherwise indicated.
    d. Lamp Test: Push-to-test or lamp-test switch on front panel.

5. The ATS Remote Annunciator shall contain embedded web pages accessible via various web browsers with the following capabilities:

    a. Configuration for protocol and communications management with the ability of auto discovering transfer switches on network
    b. Ability to create and print customized labels for ATS names and power sources
    c. The ability to choose a continuous or periodic audible alarm with customizable interval time
    d. View detailed packet status counters i.e. transmitted received and dropped packets with the ability to reset counters
    e. ATS source name configuration page which allows users to configure power source names and print labels
    f. Upgrade firmware from Ethernet network without interrupting equipment operation

6. Communications: Dual 10/100 Base-T (RJ-45) Ethernet ports are provided to support TCP/IP communications for up to eight automatic transfer switches via individual remote connectivity modules or daisy-chained serial modules into a single Connectivity Module. Additional features include:

    a. Supports Full Duplex Flow Control (IEEE 802.3x)
    b. 3.3V power supply with 5V I/O tolerance
    c. Supports 3 LEDs to indicate traffic link speed and collision

7. The ATS Remote Annunciator is suitable for surface mounting using mounting screws studs
8. The ATS Remote Annunciator shall be capable of accepting 24VDC, 120 VAC or 240 VAC power source.
   The ATS Remote Annunciator shall have an Ambient Operating Temperature range of -4 º to 158 º F (-20 º to +70 º C) @ 5~85% humidity and Ambient Storage Temperature of -40 º to 185 º F (-40 º to 85 º C).

2.6 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency and legally required systems. Include results of test for the following conditions:

    a. Overvoltage.
    b. Undervoltage.
    c. Loss of supply voltage.
    d. Reduction of supply voltage.
    e. Alternative supply voltage or frequency is at minimum acceptable values.
    f. Temperature rise.
    g. Dielectric voltage-withstand; before and after short-circuit test.
    h. Overload.
    i. Contact opening.
    j. Endurance.
    k. Short circuit.
    l. Short-time current capability.
    m. Receptacle withstand capability.
    n. Insulating base and supports damage

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install transfer switches in accordance with manufacturer's written instructions, as shown on the drawings and as specified herein.

B. Thoroughly examine site conditions for acceptance of transfer switch installation to verify conformance with manufacturer and specification tolerances. Do not commence with installation until all conditions are made satisfactory.

C. Tighten electrical connectors and terminals; including screws and bolts, in accordance with equipment manufacturers published torque-tightening values for equipment connectors. Where manufacturers torque requirements are not indicated, tighten connectors and terminals to comply with tightening torque specified in NETA Standard Tables.

D. Mark torque bolt heads using red or pink paint.

E. Freestanding transfer switches shall be accurately aligned, leveled and bolted in place on full-length channels securely fastened per the structural engineer's calculations.

F. Replace any panel pieces, doors or trims having dents, bends, warps or poor fit that may impede ready access, security or integrity.

G. Conduits terminating in concentric, eccentric or oversized knockouts at transfer switch shall have ground bushings and bonding jumpers installed interconnecting all such conduits and the switch enclosure.

H. Floor-Mounting Switch: Anchor to floor by bolting.

1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for seismic control devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
3. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Transfer switches shall be anchored and braced to withstand seismic forces calculated per Section 260548.
4. Provide workspace and clearances required by NFPA 70.

I. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

J. Identify components according to Section 260553 "Identification for Electrical Systems."

K. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

L. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, motor controls, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Route and brace conductors according to manufacturer's written instructions. Do not obscure manufacturer's markings and labels.

G. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."

H. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches (457 mm) in length.

3.3 FIELD QUALITY CONTROL

A. Administrant for Tests and Inspections:
   1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

   1. After installing equipment, test for compliance with requirements according to NETA ATS.
   2. Visual and Mechanical Inspection:

      a. Compare equipment nameplate data with Drawings and Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding, and required clearances.
      d. Verify that the unit is clean.
      e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
      f. Verify that manual transfer warnings are attached and visible.
      g. Verify tightness of all control connections.
      h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:

         1) Use of low-resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.

      i. Perform manual transfer operation.
      j. Verify positive mechanical interlocking between normal and alternate sources.
      k. Perform visual and mechanical inspection of surge arresters.
      l. Inspect control power transformers.

         1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
         2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
         3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

   3. Electrical Tests:

      a. Perform insulation-resistance tests on all control wiring with respect to ground.
      b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
      c. Verify settings and operation of control devices.
      d. Calibrate and set all relays and timers.
      e. Verify phase rotation, phasing, and synchronized operation.

f. Perform automatic transfer tests.
g. Verify correct operation and timing of the following functions:

1) Normal source voltage-sensing and frequency-sensing relays.
2) Engine start sequence.
3) Time delay on transfer.
4) Alternative source voltage-sensing and frequency-sensing relays.
5) Automatic transfer operation.
6) Interlocks and limit switch function.
7) Time delay and retransfer on normal power restoration.
8) Engine cool-down and shutdown feature.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

a. Check for electrical continuity of circuits and for short circuits.
b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation.

5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.

a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
b. Simulate loss of phase-to-ground voltage for each phase of normal source.
c. Verify time-delay settings.
d. Verify pickup and dropout voltages by data readout or inspection of control settings.
e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

a. Verify grounding connections and locations and ratings of sensors.

C. Perform ATS functional tests:

1. Simulate loss of normal power.
2. Return to normal power.
3. Simulate loss of emergency power.

4. Simulate all forms of single-phase conditions.
5. Monitor and verify correct operation and timing of the following simulations:
6. Normal voltage sensing relays
7. Engine start sequence
8. Time delay upon transfer
9. Alternate voltage-sensing relays
10. Automatic transfer operation
11. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
12. Interlocks and limit switch function
13. Time delay and retransfer upon normal power restoration
14. Engine cool-down and shutdown feature

D. Coordinate tests with tests of emergency standby power sequence of operations and run them concurrently, were approved by commissioning agent.

E. In the event the system fails to function properly during the testing, as a result of inadequate pretesting or preparation, the contractor shall bear all costs incurred by the necessity for retesting including test equipment, transportation, subsistence and the commissioning agent’s hourly rate.

F. Transfer switches will be considered defective if they do not pass tests and inspections. Replace at no additional costs to the owner all devices that are found defective or do not operate within factory specified tolerances. Remove and replace malfunctioning units and retest as specified above.

G. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

H. Submit the testing agency's final report for review prior to project closeout and final acceptance by the Owner’s Representative. Test report shall indicate test dates, devices tested, results, observation, deficiencies and remedies. Test report shall be included in the operation and maintenance manuals.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

End of Section

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Section 26 43 13

SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:

1. Type 1 surge protective devices.
2. Type 2 surge protective devices.
3. Enclosures.
4. Conductors and cables.

B. Related Requirements:

1. Section 262413 "Switchboards" for integral SPDs installed by switchboard manufacturer.
2. Section 262416 "Panelboards" for integral SPDs installed by panelboard manufacturer.

1.3 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: air of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. NRTL: Nationally recognized testing laboratory.

F. OCPD: Overcurrent protective device.

G. SCCR: Short-circuit current rating.

H. SPD: Surge protective device.

I. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.

J. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.

K. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include electrical characteristics, specialties, and accessories for SPDs.
2. NRTL certification of compliance with UL 1449.

a. Tested values for VPRs.
b. Inominal ratings.
c. MCOV, type designations.
d. OCPD requirements.
e. Manufacturer's model number.
f. System voltage.
g. Modes of protection.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace SPDs that fail in materials or workmanship within **five** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. ASCO Power Technologies
2. Emerson; Liebert
3. Current Technology Inc.
4. Square D

B. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. Comply with UL 1449.

E. MCOV of the SPD shall be the nominal system voltage.

F. Unit Status Indicators—SPD shall have an integral status circuit that monitors the operational status of all modes of protection, including Line to Neutral, Line to Ground and Neutral to Ground. No manual testing is required to confirm the integrity of the suppression and filter systems. The SPD shall be equipped with red and green solid state indicators mounted within the enclosure and be externally visible.

G. The SPD shall have the following monitoring options.

1. Time Date stamp, duration and magnitude for surges
2. SPD monitoring shall track surge protection and display it as a percentage
3. SPD shall provide a surge counter with three categories to be defined as
4. Low Level surge (100A-500A) Medium Level surge (500A-3,000A) High Level surge (>3,000A)
5. Remote communications via ModBus or Ethernet

2.2 SERVICE ENTRANCE SUPPRESSOR

A. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1 suitable for type 1 or type 2 applications.

1. SPDs with the following features and accessories:

a. Integral disconnect switch.
b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
c. Indicator light display for protection status.
d. Form-C contacts rated at 5 A and 250-V ac & 2 A and 24-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
e. Surge counter.

B. Comply with UL 1283.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 500 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Verify compatibility of peak surge current rating and VPR. Protection modes and UL 1449 VPR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 208Y/120 V.
3. Line to Line: 1000 V for 208Y/120 V.

E. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 1000 V.
3. Line to Line: 1000 V.

F. SCCR: Equal or exceed 200 kA.

G. Inominal Rating: 20 kA.

H. Electrical Noise Filter- each unit shall include a high performance EMI/RFI noise rejection filter. Noise attenuation for electric noise shall be as follows using the MIL-STD-220B insertion loss test method.

1. 100 kHz at 33 db or better.
2. All other frequencies should be 32 db or better.

2.3 SWITCHBOARD SUPPRESSORS

A. The SPD shall be listed as Type1 SPD, suitable for use in UL 1449, Type 1 OR Type 2 applications.

B. Surge Protection Device Description: Modular design with field-replaceable module mounted externally to the Panelboard, with EMI Filtering (also known as sine-wave-tracking) type with the following features and accessories:

1. Fuses, rated at 200 thousand ampere interrupting capacity (AIC).
2. Fabrication using bolted compression lugs for internal wiring.
3. Integral disconnect capable of passing full rated surge current, or dedicated fuse or breaker.
4. Multiple suppression circuits with current sharing.
5. Field Replaceable protection module.
6. Utilizing copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
7. Utilizing wire connections to phase buses, neutral bus, and ground bus.
8. LED indicator lights for power and protection status.
9. Monitoring system capable of indicating the number of transient surges, over voltages, under voltage events.

10. Audible alarm, with silencing switch, to indicate when protection has failed.
11. Dual set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status. Coordinate with the building power monitoring and control system.
12. Field testable with test data from factory provided for comparison
13. Senses percentage of protection available indicating true protection level available
14. Monitors neutral-to-ground voltage and current

C. Peak Single-Impulse Surge Current Rating:

1. Switchboard rated1200 Amps and above; 200 kA per mode/400 kA per phase
2. Switchboard rated 1000 Amps and below; 150 kA per mode/300 kA per phase

D. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:

1. Line to Neutral: 700 V for 208Y/120 V.
2. Line to Ground: 700 V for 208Y/120 V.
3. Neutral to Ground: 700 V for 208Y/120 V.
4. Line to Line: 1200 V for 208Y/120 V.

E. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 700 V.
3. Neutral to Ground: 700 V.
4. Line to Line: 1200 V.

F. Inominal Rating: 20 kA.

G. Electrical Noise Filter- each unit shall include a high performance EMI/RFI noise rejection filter. Noise attenuation for electric noise shall be as follows using the MIL-STD-220B insertion loss test method.

1. 100 kHz at 33 db or better.
2. All other frequencies should be 32 db or better.

2.4 PANELBOARD SUPPRESSORS

A. The SPD shall be listed as Type1 SPD, suitable for use in UL 1449, Type 1 OR Type 2 applications.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

B. Peak Surge Current Rating:

1.	Panelboards rated 600 Amps & above	150 kA per mode/300 kA per phase.
2.	Panelboards rated 400 Amps Buss	125 kA per mode/250 kA per phase.
3.	Panelboards rated 225 Amps Buss	100 kA per mode/200 kA per phase.
4.	Panelboards rated 100 Amps Buss	80 kA per mode/160 kA per phase.

C. Protection modes and UL 1449 VPR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V for 208Y/120 V.
2. Line to Ground: 700 V for 208Y/120 V.
3. Neutral to Ground: 700 V for 208Y/120 V.
4. Line to Line: 1200 V for 208Y/120 V.

D. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 700 V.
3. Neutral to Ground: 700 V.
4. Line to Line: 1200 V.

E. SCCR: Equal or exceed 200 kA.

F. Inominal Rating: 20 kA.

G. Electrical Noise Filter- each unit shall include a high performance EMI/RFI noise rejection filter. Noise attenuation for electric noise shall be as follows using the MIL-STD-220B insertion loss test method.

1. 100 kHz at 33 db or better.
2. All other frequencies should be 32 db or better.

2.5 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 12. The cover of the enclosure shall be hinged on the left side and require a tool for access to internal components. A drawing pocket shall be provided inside the door for storage of unit drawings and installation/operation manual. All monitoring indication must be visible without opening the door.

B. Outdoor Enclosures: NEMA 250, Type 4X.

2.6 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's written instructions.

C. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's written instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
2. Do not exceed manufacturer's recommended lead length.
3. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. SPDs that do not pass tests and inspections will be considered defective.

C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks in accordance with manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

A. **Engage a factory-authorized service representative to train** Owner's maintenance personnel to operate and maintain SPDs.

End of Section

Section 26 51 13

ARCHITECTURAL LUMINAIRES, SOURCES AND COMPONENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Contract Drawings, conditions of Contract (including General Conditions, Addendum to the General Conditions, Special Conditions, Division 01 Specification Sections and all other Contract Documents) apply to the work of this Section.

B. Related Sections: Division 26, and Section 26 09 23 “Architectural Lighting Control Systems” are related to this Section.

1.2 RELATED APPENDICIES: LUMINAIRE SCHEDULE AND CATALOGUE EXTRACTS ARE ATTACHED AS APPENDICES TO THIS SECTION.

1.3 SUMMARY

A. Included in the Work of this Section are labor, materials, and appurtenances required to complete the Work of this Section, as specified herein, as required by job conditions, or as indicated on drawings. The scope of this section includes general requirements for luminaires and their components, coordination, definitions, quality assurances, submittals, mockups, samples and general responsibility for a complete job.

1.4 DEFINITIONS

A. In this specification, the term "Architect" includes the Architect, Interior Designer, Landscape Architect, Construction Manager, Owner's representative and/or the Lighting Specifier, together or individually as they shall decide.

B. The term "luminaires" refers to lighting fixtures with their integrated light sources and all other components.

C. The use of the word "Approved" shall not extend the Architect's responsibilities beyond that as defined in the General Conditions.

1.5 GENERAL REQUIREMENTS

A. Provide labor, materials, and equipment for the installation of indoor luminaires, lighting equipment, control wiring, and sources as shown on the drawings and specified herein and in Related Sections. Luminaires shall be securely attached to supports.

B. Refer to architectural drawings for locations, dimensions and details, and electrical documents for quantities. Check and verify dimensions and details on drawings before proceeding with the Work. Report any inconsistencies or discrepancies .Should it appear that the Work intended is not sufficiently detailed or explained on the drawings or in the specifications, apply for further drawings or explanations, as may be necessary. Conform to these explanations in the work. If any question

arises about the true meaning of the drawings or specifications, provide timely and written questions before proceeding. Under no circumstances shall any request for extra compensation be honored where the basis of claim is such a clarification. In no case submit a bid or proceed on any Work with uncertainty. The intention of this specification and the accompanying or applicable drawings is to provide a job complete in every respect. Contractor is responsible for this result.

C. Recycling and Disposal: Existing luminaires shall be removed as directed by scope of work. Proper disposal of components, including but not limited to fluorescent lamps and ballasts containing mercury, PCBs or other toxic materials, shall be conducted according to relevant Federal, State, Local, and EPA regulations or guidelines. Provide written verification of proper disposal. Electronic components shall be recycled as electronic equipment, or as otherwise required by relevant codes or local laws.

1.6 COORDINATION

A. Luminaire locations and mounting heights as indicated on the electrical drawings are generalized and approximate. Carefully verify locations and mounting heights with Architect's drawings, reflected ceiling plans, interior elevations and other reference data prior to installation. Check for adequacy of headroom and non-interference with other equipment, such as ducts, pipes or openings. Provide timely and written notification of such conflicts before proceeding with the Work. Although the location of equipment included in the Work of this Section may be shown on the Contract Drawings in a certain place, actual construction may disclose that the location for the Work does not make its position easily and quickly accessible. In such cases, provide timely and written notification of this situation before installing this Work, and comply with installation directions.

B. Clearly indicate the Work to be performed by other trades' contractors, and the materials that are adjacent to or abutting the Work of this Section. Coordinate as required. Give ample notice of special openings required for placing equipment in the building, in order to avoid cutting of completed Work. Provide the materials and labor for Work included under this Section in ample time, and in sufficient quantities so that all of the Work may be installed in proper sequence to avoid unnecessary cutting of the floors and walls. Schedule the Work to prevent Work of this Section being damaged by other construction operations. Remove and replace Work so damaged at no cost to the project.. Coordinate and schedule the Work of this Section with the Work of other Sections and Utility Companies so that there shall be no delay in the proper installation and completion of any part of each respective Work. Construction Work shall proceed in its natural sequence without unnecessary delay caused by the Work of this Section.

C. Coordinate with other contractors regarding attachment to or openings in the materials of other trades such as pre-cast concrete, ornamental metals, or wood panels for recessed junction boxes, and other equipment.

D. Arrange the installation in proper relation to other Work and with architectural finishes so that it shall harmonize in service and appearance and so that there shall be no interference with the Work of others, including interference in location or level.

E. Where a catalog number and a narrative or pictorial description are provided, the written description shall take precedence and prevail.

F. Where Work of this Section is to be flush or concealed, install it to assure that it does not project visually or physically beyond the finished lines of floors, ceilings or walls.

G. Verify ceiling conditions and provide appropriate mounting details for each luminaire. Submit mounting details for approval.

H. Become familiarized with all equipment listed in the luminaire schedule and take responsibility for the successful completion of the entire lighting installation.

I. Verify compatibility of supply voltage indicated on electrical drawings with voltage specified for each luminaire prior to release. Provide timely and written notification of any and all discrepancies.

1.7 QUALITY ASSURANCES

A. Contractor shall comply with the General Requirements related to Quality Control, in addition to the provisions herein.

B. Manufacturers: Manufacturers listed in the APPENDIX – LUMINAIRE SCHEDULE (lighting fixture schedule) herein, shall be assumed capable of supplying the listed luminaires unless exceptions are set forth in their quotations. Provide timely and written notification of any such exceptions. Acceptable manufacturers are listed in the luminaire schedule. Acceptable manufacturers shall be capable of providing proof of satisfactory production of luminaires of the type and quality shown for a period of at least five years.

C. Statement of Application:

1. By commencing the Work of this Section, the Contractor assumes overall responsibility, as a part of the warranty of the Work, to ensure that assemblies, components and parts shown or required within the Work of this Section, comply with the Contract Documents.
2. Warranty: In addition to any warranties required by the General Requirements, the Contractor of the Work of this section shall:
    a. For a period of one year after Owner's initial acceptance and establishment of the beginning date of the warranty period, and at no additional cost, promptly provide and install replacements for luminaires or components thereof which are defective in materials or workmanship under normal operating conditions, except for sources; or successfully repair installed equipment at the job site. For any time during the warranty period that luminaires are not fully functional due to defects in materials or workmanship, provide or pay for and install and remove suitable and adequate temporary luminaires. Warrant replacement luminaires or components to be free of defects in workmanship or materials for a period of one year following replacement, and replace any defective replacements.
    b. Contractor shall not be held responsible for acts of vandalism or for abnormal or accidental abuse of the luminaires or their components occurring after the beginning of the warranty period, nor shall Contractor be held responsible for deleterious effects caused by maintenance procedures performed without the concurrence of Contractor.

D. Equipment Compatibility:

1. For all similar luminaire type, provide luminaires, power supplies, LED drivers, ballasts and other components fabricated or supplied by a single manufacturer, to simplify maintenance and replacement of equipment. Under no circumstances shall sources of the same type, even if different wattages, be supplied by more than one manufacturer unless operable samples are submitted, reviewed and approved in writing.
2. Luminaire details shown may be modified by the manufacturer provided all of the following conditions have been met:
   a. Luminaire performance is equal or improved.
   b. Structural, mechanical, electrical, safety, and maintenance characteristics are equal or improved.
   c. Cost to the Owner is reduced or equal.
   d. No conformance to codes has been compromised.
   e. No performance criteria for, LEED, or WELL Building ratings has been compromised.
   f. Modifications have been reviewed and approved in writing.

E. Regulatory Agencies:

1. Provide luminaires constructed, wired and installed in compliance with the current edition of applicable city, state and national codes. Provide luminaires conforming to or exceeding Underwriters Laboratories (UL) standards, and to provisions of applicable codes which exceed those standards.
2. For any category of luminaire tested by any of the following labs, provide luminaires listed and labeled by an independent Nationally Recognized Testing Laboratory (NRTL) such as UL, ETL, CSA, MET
3. In addition, provide luminaires which conform to additional regulations necessary to obtain approval for use of specified luminaires in locations shown. Use only electrical components listed by the above NRTLs.

F. Recognized Standards: In addition to standards that may be referenced in Division 01 Specification Sections, luminaires shall comply with the applicable standards of the following organizations.

Underwriters Laboratories (UL)

National Electrical Code (NEC)

Certified Ballast Manufacturers Association (CBM)

Illuminating Engineering Society (IES)

American Society for Testing and Materials (ASTM)

American National Standards Institute (ANSI)

National Electrical Manufacturers Association (NEMA)

International Electrotechnical Commission (IEC)

National Electrical Safety Code (IEEE C2)

1.8 BIDDING

A. Follow bidding procedures as described in Division 01 of this specification.

B. Provide specified and alternate unit prices separated from installation costs as required in APPENDIX - LUMINAIRE SCHEDULE (the lighting fixture schedule).

1.9 SUBSTITUTIONS:

C. Luminaires included under this Section are specified by approved manufacturer and type. Provide equipment exactly as specified, unless substitutions are mutually agreed upon, as follows:

1. Any proposed substitutions must be accompanied by full point-by-point calculations and auxiliary documentation demonstrating that the proposed luminaires fully meet the criteria in each specific application.
2. Substitutions will only be considered for luminaire descriptions where the words "or approved equal" are explicitly stated.
3. Substitutions shall not be considered that may compromise the performance criteria for LEED, WELL Building or other project requirements. If impact is not clear, submit verification and/or calculations or manufacturers data demonstrating equivalent performance.
4. Submit a written request for luminaires proposed for substitution, at least two weeks before the end of bid period – the “substitution period”. Make the request for substitution an alternate, separate proposal, accompanied by complete descriptive and technical data. Indicate if there is any addition or deduction from the base bid. Substitutions proposed after this time, or not including proper documentation shall not be considered. Submissions of substitutions may be accepted, or rejected without explanation. -.
5. Exceptions: During the construction period, no substitutions shall be considered unless compelling reasons are given - such as a specified product no longer being available. If Contractor has failed to follow the schedule presented under the Paragraph titled "Submittals" below, no substitutions will be allowed based on inability of specified manufacturer to meet delivery schedule, and the Contractor shall provide luminaires exactly as specified without delay to the project and without additional cost to Owner.
6. Substitutions shall be indicated as such in the bid documents, and operable (plug-in) samples, catalogue cuts and complete photometric reports by independent testing laboratories submitted. A complete comparison of the performance of the proposed substitution in relation to the performance of at least the first named specified product shall be included. In addition, for any luminaire type of which six (6) or more of the luminaires are to be used, submit computer generated point-by-point calculations for illumination on vertical and horizontal planes. Such calculations shall include either the typical mounting condition for the subject luminaire or a specialized mounting condition deemed critical for the success of the design.
7. Written documentation shall clearly show that the proposed manufacturer complies with each and every aspect of the specification and/or indicate any exceptions or variations. Where proposed substitutions alter the functional or visual design, or change the space requirements or mounting details indicated

herein or on the drawings, such changes shall be detailed in the proposal and costs indicated for revised design and construction for trades involved. Cost data shall be provided as called for in the General Requirements. Submittal shall include names and addresses of at least three (3) similar projects on which the product was used, including names and phone numbers of specifiers and owners of each project, and dates of installation.

D. Value Engineering:

1. To the extent that Value Engineering is allowed in the General Requirements, the procedure for value engineering is the same as outlined above regarding the substitution process, with the words "value engineering proposed substitution(s)" replacing the word "substitution(s)". Value engineering submittals shall be clearly separated from substitutions, and line item cost savings for each proposed luminaire type clearly documented.

1.10 SUBMITTALS

A. General:

1. For standard catalog items with no modifications, submit catalog cut sheets prepared by the manufacturer which clearly show all elements to be supplied and all corresponding product data (including sources, manufacturer and model number of power supply, LED driver, ballast, and other components, as well as voltage; accessories, options and any miscellaneous items detailed in the written description of the specification.) If cut sheet shows more than one (1) luminaire type, all non-applicable information shall be crossed out.
2. For custom luminaires, modified luminaires or linear luminaires mounted in continuous rows, submit a layout drawing prepared by the manufacturer showing all details of construction, lengths of runs, source layout, if applicable, suspension installation hardware or components, power locations, remote power supplies, remote LED drivers, remote transformers, finishes and list of materials. Drawings must be to scale. Provide manufacturer with field dimensions where required. If scallop shields, wallwash reflectors or baffles are required, drawings shall indicate relative position to wall or adjacent vertical surface.
3. When components are indicated as contractor supplied or specified (i.e. remote power supplies, remote LED drivers, ballast housings, NEMA enclosures, etc., provide submittals for components in conjunction with the luminaire submittal.
4. Provide submittals with luminaire installation instruction sheets.

B. Submittal Schedule (Note: All days, week or months listed are "calendar" days, weeks or months, and not working days, weeks or months):

1. List of Intended Manufacturers: Within fifteen (15) calendar days of the Notice to Proceed, submit a List of Intended Manufacturers, with estimated fabrication lead times. "Lead times" shall be measured in weeks, beginning from the manufacturer's receipt of approved shop drawings and release, and ending at shipment. The response to this list will indicate if any manufacturers are unacceptable.
2. Acknowledgments and standard shop drawings: Within twenty (20) days after receipt of the response to the list of Intended Manufacturers, submit copies of purchase orders and manufacturers' acknowledgments for all luminaires

specified, conforming to responses. The purchase orders and the manufacturer's acknowledgments need not list prices, but shall contain a guaranteed fabrication lead time, in weeks, as defined above. These fabrication times shall be adequate for the timely completion of the job. At the same time, but not less than twenty four (24) weeks before standard manufactured luminaires are required on the site, submit shop drawings for all standard luminaires or those with minor modifications.

3. Custom Shop Drawings: In order to allow for mockups and independent testing for all custom luminaires or those with major modifications, submit complete shop drawings within sixty (60) days after the Notice to Proceed, but not less than eleven (11) months prior to the time they are required on the site.
4. Release for fabrication: Within twenty (20) days after receipt of shop drawings marked "No Exceptions Taken" or "Make Corrections Noted", release luminaires for fabrication and forward verification that the luminaires have been released for fabrication, with a guaranteed shipment date for each specified luminaire. At the same time, forward finish or component samples, tests, or any outstanding data required for approval.
5. Operable luminaire samples and mockups as indicated in APPENDIX - LUMINAIRE SCHEDULE (the lighting fixture schedule) shall be received by the designated parties, or installed on the site, within forty-five (45) days after Contractor's receipt of shop drawings marked "No Exceptions Taken" or "Make Corrections Noted".
6. Re-submissions: Within fourteen (14) days after receipt of shop drawings marked "Revise and Resubmit" or "Rejected", resubmit revised shop drawings in accordance with the General Requirements regarding re-submissions.
7. Provide written notification of any potential scheduling problems, or of any submittals that have not been returned which are required to maintain the installation schedule. Such notification shall be in a timely manner and well in advance of the time such delay might affect the fabrication schedule or appropriate delivery of luminaires.
8. Request for Final Layout: At the same time that shop drawings are submitted, request verification of final layouts and control zones for all luminaires. Submit templates for labeling of all controls. Layout adjustments shall be considered no-cost clarification as long as the quantity or value of luminaires does not increase. Provide blank control station faceplates until labels are available. Custom engraved or labeled faceplates shall be ordered from the manufacturer so that they arrive prior to the final release of the space and subsequent beginning of the warranty period. Blank faceplates shall be replaced with custom labeled faceplates at no additional cost to the project.

C. Shop Drawings:

1. Submit shop drawings for each type of luminaire, arranged in order of lighting type designation except where specified luminaires are standard, unmodified, "off-the-shelf" units, fully described by catalogue cuts. If comprehensive, such catalogue cuts may be substituted for shop drawings, however full shop drawing shall be submitted upon request. Submit catalogue cuts of individual lamps or replaceable source modules to be provided for each luminaire. Submit shop drawings in the quantity and format called for in the General Requirements.

2. Shop drawings shall show all luminaire components, including but not limited to lampholders, reflectors, louvers, lenses, fuses, junction boxes, power supplies, ballasts and sources. Shop drawings shall show materials, finishes, metal gauges, overall and detailed dimensions, sizes, electrical and mechanical connections, fasteners, welds, joints, any exposed hardware, and conditions, or provisions for the work of others, and similar information. Indicate complete details of the luminaire, including manufacturer's name and catalogue numbers for sockets, power supplies, LED drivers, ballasts, light shields, switches and type of wiring, and targeting and locking devices for adjustable luminaires. Indicate that source type specified is appropriate for luminaire design. Indicate maximum allowed distance between light luminaire and remote power supply. Indicate type and extent of approved inert insulating materials to prevent electrolytic corrosion at junctions of dissimilar metals. Include pertinent mounting details including hung ceiling construction. Standard catalogue cuts shall be supplemented by additional drawings if information or descriptions listed above are not included in the cuts. Photometric documentation and finish samples shall be provided upon request. Samples shall be provided if indicated in APPENDIX - LUMINAIRE SCHEDULE (the lighting fixture schedule). No luminaires will be approved without the previous described submission of data. Submissions may be modified during the submission review process. Luminaires or other materials shall not be fabricated, shipped, stored or installed unless prior written approval has been received.
3. Submit layouts for continuous luminaires or coves, indicating overall field measurements and proposed lengths, and condition of joints, corners, ends and any unlighted lengths.
4. Submit catalogue cuts for all lamps, power supplies, LED drivers, ballasts and emergency battery backup power supplies and ballasts.

D. Data: Submit independent laboratory photometric data in the directed number of copies and in format as directed. Photometric data shall be submitted for standard, "off-the-shelf" units at the time the manufacturer's cuts are submitted. Photometric testing and reporting shall conform to IESNA procedures. Submit additional photometric testing as required by Luminaire Schedule or upon request.

E. Manufacturer's Catalogue Sheets shall indicate input watts and electrical characteristics, ambient temperature rating, noise level rating, mounting methods and UL or ETL listing for use with required source, power supply, LED driver, transformer, lamp and/or ballast (if any).

F. For Guaranteed Maximum Pricing (G.M.P.)SUBMIT A DETAILED BREAKDOWN OF BID BY MATERIAL COST, LABOR, AND WIRING AND QUANTITIES FOR EACH LUMINAIRE, WHEN REQUESTED.

1.11 SAMPLES

A. After shop drawings, data and any other required submissions have been approved, submit samples of each of the following components upon request:
1. Samples demonstrating the finishes of any custom metal, paint color or finish. Sample size to be a minimum of 4in square. Place labels on the back side of finish samples only.

2. Material samples of any transmitting media, such as plastic, glass, perforated metal and the like. Sample size to be a minimum of 12in square, to allow adequate space for label.
3. Each downlight reflector cone that differs in size or finish.
4. Any other luminaires or components requested in the luminaire descriptions, schedule, or in the contract documents.

B. Submit two (2) samples unless otherwise indicated. If luminaire samples are requested, supply a completely operable luminaire as specified in the Luminaire Schedule and/or incorporating responses to shop drawing, with the specified source and a 10ft cord and plug for standard 120 volt service. For 277 volt luminaires, also supply a completely wired or plug-wired step-up transformer to convert from 120 to 277 volts, with a 120 volt cord and plug. Provide component parts as specifically requested.

C. Where a sample is submitted or requested, do not fabricate that luminaire type until the sample is approved. Submit and resubmit a sample as required, until samples are approved.

D. The purpose of the sample is to review manufacturing techniques, detailing, light source, and scale. Minor modifications, if any, shall be considered part of these Specifications and shall be accomplished at no additional cost.

E. Submit complete and operable sample luminaires for any proposed substitution or value engineering proposal as indicated above. There shall be no expectation that substitution products or samples received after the substitution period will be accepted or reviewed. .

F. Provide samples as called for in the General Requirements. Tag samples with the name of the project, referenced specification, paragraph or drawing number, the luminaire type number and any other identifying data. Ship the samples to two separate addresses as requested. After review, the samples shall be shipped to the project site for use as standards. All transportation charges for samples shall be paid by Contractor. Make luminaires supplied under the Work of this Section identical with approved samples. Do not install any sample luminaires in the project.

G. If sample submissions are not approved, samples shall be returned to Contractor, at Contractor's expense. Upon receipt of sample disapproval, immediately make a new submission of samples meeting the comments and contract requirements, as called for in the General Requirements.

1.12 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Luminaires and their component elements shall be delivered to the job site factory-assembled and wired to the greatest extent practical, in strict accordance with the approved shop drawings, samples, certificates and catalogue cuts, and shall be handled in a careful manner to avoid damage.

B. Exposed finishes shall be protected during fabrication, transport, storage and handling. Delivered materials shall be identical to the approved samples. Materials which become damaged shall be repaired and/or replaced as directed.

C. Luminaires shall be stored under cover, above the ground, in clean, dry areas, and shall be tagged and/or marked as to type and location.

D. Delivered luminaires shall include wiring, sockets, power supplies, LED drivers, ballasts, shielding, channels, lenses and other parts and appurtenances necessary for luminaire installation of each luminaire type.

1.13 MOCK-UP

A. As a part of the Work of this Section, when specifically called for in the Luminaire Schedule, and at no additional cost to project, temporarily install, connect and adjust a reasonable number of luminaires, three (3) unless otherwise stated. Install completely operable luminaires with all sources, power supplies, LED drivers, ballasts, etc., of each type listed in the Luminaire Schedule where a mock-up is specified, to verify the specified catalogue number and requirements. Place the mock-up luminaires where and when directed. Remove and store mock-up luminaires, when approved, as necessary to complete the work, at Contractor's expense.

1. The mock-up installation shall closely conform to the conditions of the actual installation as to: height, distance from ceiling, light source type, output and performance, number and type of sources, material, color, and space finishes, etc. Submit a written description of each proposed mock-up with drawings to obtain approval prior to commencement of each mock-up.
2. Where mounting of mockup may negatively impact existing conditions or constructed scope of Work, temporary mounting methods shall be implemented to avoid any damage.
3. The purpose of the mock-up will be to study the general appearance and performance of the intended lighting systems unless otherwise indicated. At that time, certain minimal test variations may be requested as to lamp location, source type, reflector shape, color, etc. Final modifications, if any, shall be considered as part of these Specifications and shall be accomplished with no additional cost to the project.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide materials, equipment, appurtenances and workmanship for the Work of this Section conforming to the highest commercial standards, as specified and indicated on the drawings. Make luminaire parts and components not specifically identified or indicated on the drawings, of materials most appropriate to their use or function, and resistant to corrosion and to thermal and mechanical stresses encountered in the normal application and function of the luminaires.

B. Provide recessed luminaires that are constructed to be suitable for and compatible with the ceiling, wall, pavement or other materials and construction in which they will be installed.

C. Named manufacturers, when listed in the luminaire schedule, are representative of an adequate level of quality and reputation, and are allowed to submit a product, provided that they are capable of satisfying the provisions of the specifications in every respect. This does not mean that any standard product provided by that

manufacturer is automatically qualified. Manufacturers not on this list may be proposed during the substitution period if they can substantiate that their product meets every particular of the relevant specification, and are of comparable quality, experience and reputation. See the paragraph titled "Substitutions", above. Any submitted product may be rejected without explanation.

2.2 DEFINITIONS:

A. CCT: Correlated Color Temperature

B. CRI : Color Rendering Index

C. Fixture: See “Luminaire”

D. IP: International Protection or Ingress Protection Rating

E. LED: Light Emitting Diode

F. Lumen: Measured output of source and luminaire or both

G. Luminaire: Complete lighting unit, including source, gear, reflector and housing

2.3 MARKING OF LUMINAIRES

A. Luminaires shall be equipped with markings showing safety specifications, construction safeguards, and minimum resistance to hazard sources operation under fault conditions. Marking shall include manufacturer/distributor’s name, related voltage or voltage range, rated wattage, light output, optical distribution and rated frequency. LED luminaires not suitable for dimming control are required to indicate this clearly in installation instructions or package labelling. Mark luminaires with replaceable sources according to proper source type. Provide markings that are clear and that are located to be readily visible to service personnel, but invisible from normal viewing angles when sources are in place.

2.4 MATERIALS AND FABRICATION

A. Provide luminaires completely factory-assembled and wired and equipped with necessary sockets, power supplies, LED drivers, ballasts, wiring, shielding, reflectors, channels, lenses, integral emergency battery packs (if required) and other parts and appurtenances necessary. Deliver to project site ready for installation and to complete the luminaire installation.

B. Use only completely concealed hardware, unless otherwise noted. Latching of luminaire door frames shall be unobtrusive. Make luminaire free from light leaks by the inherent design of the luminaire body and frame. Bond gaskets, when used, to the luminaire metal. Weld power supply support studs, socket saddle studs and reflector support studs to luminaire body. Flexible leads shall enter luminaires at sides, unless otherwise noted.

C. Minimum gauges sheet steel: 22 gauge for recessed LED and fluorescent, unless thicker gauge required by regulating agency; 18 gauge for unit downlights, unless otherwise specified.

D. Construct luminaires with the minimum number of joints. Make unexposed joints by approved method such as welding, brazing, screwing or bolting. Soldered joints are not acceptable.

E. Provide metallic cast or extruded parts of luminaires that are close grained, sound, and free from imperfections or discoloration. Provide cast or extruded parts that are rigid, true to pattern, and of ample weight and thickness. Provide cast or extruded parts that are properly fitted, filed, ground, and buffed finished surfaces and joints free of imperfections. Make thickness on cast parts not less than 1/8in.

F. Provide housings that make electrical components easily accessible and replaceable, without removing the luminaire body from its mounting.

G. Provide luminaires indicated as "continuous" on drawings or specifications with finished end-to-end or wall-to-wall appearance. Verify run lengths per field conditions prior to ordering. Maximize lighted length to nearest six inches (152mm), with equally spaced unlighted portions at each end, not to exceed 3 inches each. Provide continuous louvers and/or lenses into unlighted ends and at corners.

H. Wiring:

1. Provide luminaire wiring between sources, lampholders and associated operating and starting equipment in compliance with UL 1570 and NEC, UL 8750 for LED’s.
2. Make connections of wires to terminals of sources, lampholders and other accessories in a neat and workmanlike manner and which are electrically and mechanically secure, with no loose strands protruding. Provide of the appropriate amount of wires extending to or from the terminals of a source, lampholder or other accessory. These wires shall not be in excess of the number which the accessory is designed to accommodate.
3. Provide wiring channels and wireways free from projections and rough or sharp edges throughout. At points or edges over which conductors shall pass and may be subject to injury or wear, grind to make a smooth contact surface with the conductors. Install insulated bushings at points of entrances and exit of flexible wiring.

I. All interior luminaires shall be UL/ETL/CSA-US listed, “DampLocation” rated at a minimum, with greater protection (UL/ETL/CSA-US “Damp Location” or “Wet Location”) as appropriate or required by code for the application.

2.5 FINISHES

A. The paint finish/color may affect the heat dissipation from luminaires. Apply luminaire finishes after fabrication in a manner that assures a durable wear-resistant surfacing. Prior to finishing, hot clean the surfaces by accepted chemical means, and treat them with corrosion inhibiting (phosphating) treatment to assure positive paint-adhesion. Give exposed metal surfaces (brass, bronze, aluminum and others) and finished castings except chromium-plated or stainless steel parts an even coat of high grade methacrylate lacquer, or transparent epoxy. Anodize exposed aluminum surfaces for corrosion resistance. Make sheet steel luminaire housing, and iron and steel parts which have not received phosphating treatment, or which are to be utilized in exterior applications corrosion resistant by zinc or cadmium plating or hot-dip zinc galvanizing after completion of all forming, welding, or drilling operations.

B. Electroplate parts operated under temperatures injurious to hot-dipped galvanizing.

C. Cadmium plate screws, bolts, nuts and other fastening or latching hardware.

D. Except where otherwise indicated provide luminaires with a final synthetic, high-temperature baked enamel coating of color and finish as specified or directed. Unless otherwise specified, provide white baked enamel "reflective" surfaces, with a minimum reflectance of 86 percent. Unless otherwise specified, provide potentially visible non-reflective surfaces with a matte-black baked enamel finish. Prior to painting give all parts proper etched surface preparation to assure paint adherence and durability.

E. Exterior Fixture Finishes:
1. Unless otherwise specified, all painted surfaces shall have an outdoor life expectancy of not less than 20 years. Surfaces shall be prepared, primed, and material applied in accordance with the manufacturer's requirements.
2. Color: Colors shall be as specified under Section 26 5113 Appendix A Lighting Fixture Descriptions/Schedule.

2.6 COMPONENTS

A. General:
1. Provide identical power supply and gear within each luminaire type. Provide power supplies and gear that are suitable and UL-listed for the electrical characteristics of the supply circuits to which they are to be connected and which are suitable for operating LED or relevant light sources, including future LED replacement lamps.
2. Unless otherwise specified, provide power supplies and control gear of same type and same manufacturer for ease of stocking and replacement.
3. Components shall be configured and installed in luminaire by the luminaire manufacturer.
4. Components shall not contain Polychlorinated biphenyls (PCBs) and shall be labeled “No PCBs”.
5. Gear housing shall be constructed of painted metal with no sharp edges.
6. Provide only luminaires whose design, fabrication and assembly prevent overheating or cycling of light engines or power supplies under any condition of use.
7. Electronic ballasts shall meet the requirements of the Federal Communications Commission Rules and Regulations, Part 18, Part C (RF Lighting Devices) Non-consumer equipment, regarding radio frequency interference (RFI) (radiated) and electromagnetic interference (EMI) (power line conducted).
8. Submit gear details with luminaire shop drawings.

B. LED Emergency Lighting:
1. Battery-backed LED emergency lighting luminaires shall consist of a normal LED luminaire with some or all of the LEDs connected to a battery and charger.

a. The battery shall be nickel cadmium or lithium-ion and sized for a minimum of 90 minutes of luminaire operation.
b. The charger shall be solid-state and include overload, short circuit, brownout and low battery voltage protection.
c. The battery and charger shall include self-diagnostic and self-exercising circuitry to exercise and test itself for 5 minutes every month and for 30 months every 6 months.
d. The luminaire shall include a test/monitor module with LED status indicating lights mounted so as to be visible to the public.
e. The luminaire shall not contain an audible alarm.
f. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

2. Where emergency illumination is provided by one or more directly controlled luminaires (An emergency luminaire that has a control input for an integral dimming or switching function that drives the luminaire to full illumination upon loss of normal power) that respond to an external control input to bypass normal control upon loss of normal power, such luminaires and external bypass controls shall be individually UL924 rating listed for use in emergency systems.

2.7 TRANSFORMERS FOR LOW-VOLTAGE LUMINAIRES

A. General:
1. Each transformer controlled by a dimmer shall have a suitable choke to eliminate noise during dimming.
2. Secondary wiring shall meet all requirements of this Division and of all applicable local codes. Additionally, secondary wiring shall be sized so that the total average voltage drop on the transformer secondary side does not exceed 3 percent.
3. Source operating voltage, as measured at the socket, shall be between 11.5-12.1 volt for nominal 12 volt sources, and between 23.0-24.2 volt for nominal 24 volt sources. Contractor shall demonstrate that voltage is within this range if requested.

B. Where a remote transformer is required for interior installations, provide a UL listed remote low voltage power supply which meets or exceeds the following requirements, in addition to those of Paragraph A above.
1. Power supply shall contain a toroidal transformer, primary circuit breaker, and thermal protection.
2. Power supply shall be UL listed, suitable for surface or recessed mounting in both walls and ceilings, and require zero clearance to combustible materials.

2.8 SOURCES

A. General:
1. Provide electric sources as required, during construction, including sources for luminaires provided by others.

2. Provide a complete set of new lamps (excluding LED lamps and light engines), as described in this Section and specified the Luminaire Schedule below, in each luminaire, at the completion of the Work, leaving luminaires and lighting equipment completely lamped and/or in normal operating condition. Provide spare sources in accordance with the paragraph titled “Spares”, below.
3. Submit catalogue cuts of all sources to be used in the Work, along with the shop drawing submittal.

B. Solid State Lighting / Light Emitting Diode (LED) Light Sources and Luminaires:

1. General:
   a. Luminaire manufacturer shall have a minimum of five (5) years’ experience in the manufacture and design of LED products and systems and no less than one hundred (100) North American installations.
   b. Unless otherwise specified, luminaire fabrication shall integrate all LED light sources and power/data supplies fabricated by a single manufacturer to ensure compatibility.
   c. All components peripheral devices, integrated photosensors, occupancy/vacancy sensors, controllers, even if manufactured or provided by others, shall be the responsibility of a single entity, the luminaire manufacturer. All components shall perform successfully as a complete system. Integrated controls shall be programmed onsite to operate as described in Lighting Control Intent Narrative documents or Appendix - Luminaire Schedule.
   d. Provide submittals as described in Part 1 above.
   e. Provide two (2) samples of each separate manufacturer and type of LED luminaire if requested in Appendix - Luminaire Schedule. Follow procedure for submitting samples as described in Part 1 above.
   f. Include all components necessary for a complete installation. Provide all power supplies, synchronizers, data cables, and data terminators for a complete working system.
   g. All white light LED sources within the same luminaire type shall be within two (2) MacAdam ellipses/steps of each other.
   h. All LED sources used in the LED luminaire shall be of proven quality from established and reputable LED manufacturers and shall have been fabricated within 12 months before installation per the date code on the module. Acceptable LED component or module manufacturers unless otherwise noted are:
      1) Cree, Inc.
      2) Lumileds
      3) Nichia Corporation
      4) Norlux
      5) Lextar
      6) Osram Optronic Semiconductors
      7) Xicato
      8) Bridgelux
      9) Epistar
      10) San’an

11) Citizen Electronics
12) General Electric Company
13) Soraa
14) Samsung
15) Seoul Semiconductor
16) Lumenetix
17) Ledengin

2. Replacement and Spares:
   a. Manufacturer shall provide written guarantee of the following:
      1) Manufacturer's LED system or equivalent system will be available for ten (10) years: Manufacturer will provide exact replacement parts, complete replacement luminaires, or provide upgraded parts that are designed to fit into the original luminaire and provide equivalent distribution and lumen output to the original, without any negative consequences.
      2) Manufacturer will keep record of original chromaticity coordinates for each LED module and have replacement modules or luminaires from within two (2) MacAdam Ellipses/ steps of the same coordinates available.
      3) Manufacturer will keep an inventory or ability to supply replacement parts or complete fixtures within two (2) weeks for component parts or the standard lead time of the original fixture for a complete fixture for duration of warranty period.
   b. ALL PARTS OF SYSTEM SHALL BE REPLACEABLE IN THE FIELD AS SPECIFIED IN APPENDIX - LUMINAIRE SCHEDULE.System shall carry a full warranty for a minimum of three (3) years from the date of shipment (or longer if required by the project, also refer to Division 1 – General Requirements for further warranty requirements). Manufacturer shall be responsible for a cost of labor and shipping as agreed between parties, to replace any component of the system that fails within the warranty period.
3. Products and Components – Performance
   a. LED luminaires and components shall be approved by an NRTL facility such as UL, ETL or CSA/US.
   b. For applicable fixtures: all products included in system shall use Mil-Std 810F, Random Vibration 7.698g as a minimum standard. In installations subject to vibration, luminaire shall be installed with vibration isolation hardware to sufficiently dampen vibrations.
   c. All LED components shall be mercury and lead-free.
   d. All manufacturing processes and electronic materials shall conform to the requirements of the European Union's Restriction on the Use of Hazardous Substances in Electrical and Electronics Equipment (RoHS) Directive, 2002/95/EC.
   e. LEDs shall comply with ANSI/NEMA/ANSLG C78.377-2008 – Specifications for the Chromaticity of Solid State Lighting Products. Color shall remain stable throughout the life of the source. The chromaticity of the installed product shall match IES LM-80 data showing that the LED's

do not shift more than .005 DuV from an approved sample or submitted documentation.

f. LEDs testing shall be performed in accordance with IES LM-80 - Approved Method for Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules.

g. LEDs shall have a minimum rated source life of 50,000 hours or as specified in Appendix: Luminaire Schedule. LED “rated source life” shall be determined per IES TM-21 - Projecting Long Term Lumen Maintenance of LED Light Sources based on LM-80 test data. Calculated lifetimes not exceeding testing hours per TM-21 are not accepted.

h. Luminaire assembly shall include a method of dissipating heat to prevent degradation of source life, electronic equipment, or lenses. LED luminaire housing shall be designed to transfer heat from the LED board to the outside environment. Luminaire housing shall have no negative impact on life of components. High power LED luminaires shall be thermally protected using one or more of the following thermal management techniques: metal core board, gap pad, and/or internal monitoring firmware

i. Luminaire shall be tested and suitable to operate under a minimum of two (2) case temperatures: 55°C (131°F) and 85°C (185°F) and a relative humidity under 65%.

j. Manufacturer shall supply in writing a range of permissible operating temperatures and relative humidity levels in which system will perform optimally. LEDs shall be adequately protected from moisture or dust in interior applications.

k. All hardwired power connections to LED luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed, shorted or otherwise mis-wired during the installation process.

l. LEDs shall not be overdriven beyond their specified nominal voltage and current.

m. Manufacturer shall be able to provide supporting documentation of the product meeting third party regulatory compliance.

n. Manufacturer shall ensure that products undergo and successfully meet appropriate design and manufacturability testing including Design Failure Mode & Effects Analysis, Process Failure Mode & Effects Analysis, Environmental Engineering Considerations and Laboratory Tests, IEC standards and UL/CE testing.

o. Manufacturer shall provide Luminaire Efficacy (lm/W), total luminous flux (lumens), luminous intensity (candelas), chromaticity coordinates, CCT and CRI. optical performance, polar diagrams, and relevant luminance and illuminance photometric data. Provide data in IES file format in accordance with testing standards IES LM-79-08 and IES LM-82-12, based on test results from an independent Nationally Recognized Testing Laboratory or National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory.

4. LED Control and Communication – Performance

   a. LED luminaires shall be network controllable via digital control.

b. The LED system shall use integral and differential non-linear control.

c. Constant data transmission rates shall be employed, resulting in the output being independent of distance of cable between power supply and light source within the specified length.

d. LED system shall have a selectable means of external control via a data network.

e. Each LED luminaire and/or node shall have the capability to be set to a unique and individual address. Address shall be selectable through on board switches or by an external hardware or software method.

f. The LED system shall be scalable, with every LED luminaire/address in the system capable of being controlled by a single, centralized controller.

5. All color characteristics, CCT, CRI, Color Fidelity, CIE Chromaticity Coordinates shall be consistent across the entire dimming range.

6. Luminaires shall have less than 30% flicker at frequencies of 200Hz or below at 100% and 20% light output and/or meet IEEE standard PAR 1789.

C. LED Power Supplies/ Drivers:

1. LED driver shall have a minimum 50,000 hour published life while operating at maximum case temperature and 65 percent non-condensing relative humidity.

2. Driver shall be Sound Rated A+.

3. Driver shall be > 80% efficient at full load across all input voltages.

4. Driver shall include ability to turn off at low control input rather than holding at a minimum dimming level, and shall consume 0.5 Watts or less in standby/off mode. Control deadband at low control input shall be included to allow for voltage variation of incoming signal without causing noticeable variation in luminaire to luminaire output.

5. Drivers shall track evenly across multiple luminaires at all light levels, and shall have an input signal to output light level that allows smooth adjustment over the entire dimming range.

6. Control Input:

a. 4-Wire (0-10V DC Voltage Controlled) Dimming Drivers

1) Must meet IEC 60929 Annex E for General White Lighting LED drivers.

2) Connect to devices compatible with 0 to 10V Analog Control Protocol, Class 2, capable of sinking 0.6 ma per driver at a low end of 0.3V.

3) Must meet ESTA E1.3 for RGBW LED drivers.

b. Digital (DALI Low Voltage Controlled) Dimming Drivers

1) Must meet IEC 62386.

c. Digital Multiplex 512 (DMX Low Voltage Controlled) Dimming Drivers

1) Must meet DMX / RDM: USITT DMX512A and ANSI E1.20 (Explore & Address).

2) Must be capable of signal interpolation and smoothing of color and intensity transitions.

D. Other:

1. For other luminaires, provide sources as specified. If specification is not complete, request clarification before ordering equipment.

2.9 REFLECTORS

A. Reflectors:

1. Provide reflectors and reflecting cones or baffles fabricated from aluminum/plastic reflector sheet no less than minimum thickness listed below for each application, Reflector shall be absolutely free of tooling marks including spinning lines, and free of marks or indentation caused by riveting or other assembly techniques. No rivets, springs, or other hardware shall be visible after installation.
   a. Cones: 0.0500in
   b. Wall wash kicker panels in cones: 0.0400in
   c. Reflectors (non-structural: 0.0235in
   d. Louvers/Baffles: 0.0200in
2. Provide reflectors and baffles of first-quality polished, buffed and anodized finish, "Alzak" or approved equal, and with specular or semi-specular finish color to be clear, unless specified otherwise. Provide reflector and baffles which produce no apparent brightness nor a source image, nor shall any part of the source be visible from 50° above nadir to 90° above nadir (vertical). That is, the reflector shall have a maximum 50° cutoff angle and a minimum 40° shielding angle.
3. Provide other aluminum reflectors where required, and formed and finished as noted on drawings and elsewhere in the specifications. Provide only reflectors free from blemishes, scratches, or indentations which would distort their reflective function and finished by means of the "Alzak" process, or approved equal, unless otherwise noted. No rivets, springs, or other hardware shall be visible after installation.
4. For luminaires employing multi-color sources or sources emitting more than one distinct frequency of color, provide reflectors, cones, or baffles with low iridescent coating on all surfaces seen from normal viewing angles.
5. Anodized aluminum reflectors shall have the following characteristics:
   a. Specular:
      1) 2 mg/in^2 minimum Weight of Coating (Anodizing process. Coating of aluminum oxide: Reference ASTM Test Method B-137)
      2) 86 minimum Total Hemispherical Reflectance and 70 minimum Specular Component (Reference ASTM Test Method E-903-82 (testing utilizing a TR1 or TR2 Total Reflectometer is also acceptable pending issuance of ASTM standard))
      3) 90 minimum Visual Clarify and 0.03 minimum Diffuseness at 15° (c) (Reference ASTM Test Method E-430-78 (1983))

B. Painted Reflectors:

1. Reflectors shall be completely formed before application of primer and enamel color coat or coats.

2. When requested, submit a sufficient quantity of flat steel panels having the identical primer and color coat or coats applied in the same manner as proposed for the contract items.
3. Tests will be required only in case of dispute about reflector characteristics. Tests may be required at any time before or during Contractor's warranty period. Contractor will pay the cost of tests, if required. Reflectors which do not meet the criteria expressed here will be replaced at Contractor's expense, with reflectors meeting specified requirements.
4. Tests:
    a. Painted reflectors shall have an initial reflection factor not less than 86 percent in the visible range of 400-700 nanometers as per ASTM Method E-424-71 as determined by independent laboratory test of fading, tested in the following manner: One half of sample shall be covered and remaining half shall be exposed to a 150 watt sunlamp placed 1/2in above reflective surface for 72 hours. Comparison of exposed and unexposed sides shall show no visible fading or deterioration in appearance or reflectance.
    b. The percentage of Specular Gloss shall be a minimum of 80 percent as determined by ASTM Method D-532-T, Procedure A.

2.10 LENSES / FACEPLATES / TRIM

A. Where plastic lens is indicated, provide lens of 100 percent virgin acrylic (polymethyl methacrylate), nominal 0.125in thick, unless otherwise indicated. Lens is to be strain-free, uniform in appearance, and destaticized.

B. Where clear acrylic lens is indicated, provide lens with a minimum visible light transmittance of 92 percent, unless otherwise indicated.

C. Where prismatic acrylic lens is indicated, lens shall be composed of 3/16in square non-convex prismatic cones of maximum 0.080in depth and aligned 45° to the length and width of the lens panel, unless otherwise specified. Lens shall be a minimum of 7.5 oz. per square foot. Lens shall have minimum 80 percent visible light transmittance.

D. Where diffuse acrylic lens is indicated, lens shall be diffuse frosted white, high transmission acrylic with a minimum 73 percent visible light transmittance unless otherwise indicated. Provide nominal 0.125in thick lens unless otherwise specified.

E. Where acrylic “overlay” is indicated, lens shall be supported by other rigid luminaire members, such as louvers or shelves. Lens shall be white or clear, as specified, with a minimum 79 percent visible light transmission for white lenses, and a minimum 83 percent transmission for clear lenses. Provide 0.040in thick lens unless otherwise indicated.

F. Make lenses, louvers, or other light diffusing elements contained in frames removable, but positively held within the frames so that hinging or other motion of the frame will not cause the diffusing element to drop out.

G. For recessed luminaires with trim that is removable or open for access to the interior of the luminaire, and serves as a ceiling trim, provide trim that is positively held to the luminaire body by adjustable means that permit the trim to be drawn up

to the ceiling as tight as necessary to insure complete contact of faceplate with ceiling surrounding the luminaire.

2.11 RATED LOCATION LUMINAIRES

A. General:

1. Provide luminaires designed and manufactured specifically for “rated” (e.g., damp, wet, shower, hazardous) location service. Components, including nuts, bolts, rivets, springs, and similar parts shall be made of materials of effective corrosion resistance, or of materials which have been subjected to finishing treatment which will assure such resistance.
2. Provide anodized aluminum for aluminum parts of exterior luminaires that are not specified as requiring a painted finish.
3. All luminaires shall be constructed according to UL procedures, and listed by UL ETL or CSA-US for the appropriate category.

B. Damp Location:

1. In addition to the requirements of paragraph, above, damp location luminaires shall meet or exceed the following criteria:
   a. Provide metal parts of luminaires, which are specified as requiring painting, for use in indoor, outdoor or damp locations, which are painted with suitable weather and/or moisture resisting qualities.
   b. Provide luminaires for use outdoors, or in areas designated as damp locations, which are suitably and effectively gasketed to prevent access of moisture into electrical components or enclosing diffusers, lenses or globes.
   c. Luminaires shall be UL, ETL or CSA-US listed for damp locations.

C. Wet Location:

1. In addition to the requirements of Paragraphs above, wet location luminaires shall meet or exceed the following criteria:
   a. Any exposed luminaires shall be UL, ETL or CSA/US rated for wet locations.
   b. Provide luminaires for use outdoors, or in areas designated as wet locations, which are suitably and effectively gasketed to prevent access of moisture into electrical components or enclosing diffusers, lenses or globes.
   c. Provide wet location luminaires with a suitable IP rating for their planned environment, unless otherwise specified in Appendix – Luminaire Schedule.
      1) Recessed luminaires suitable for wet location shall have a mimimum IP54 rating.
      2) Surface mounted luminaires exposed to direct rain, shall have a minimum IP65 rating.
      3) Luminaires intended to be cleaned by high pressure waterjet cleaning, shall have a minimum IP66 rating.
      4) Ground-mounted luminaires located in floodplains, shall have a minimum IP68 rating.

D. Bathtub and Shower Locations:

1. In addition to the relevant requirements of paragraphs above, “Bathtub and Shower” location luminaires shall meet all applicable local codes and standards.
    a. Luminaire shall be damp location rated.
    b. Luminaire shall be recessed or surface-mounted at or above 8’-0” above and at least 3’-0” horizontally from the highest point in the shower (threshold) or the tub (tub rim).
    c. Luminaires used in or near showers, or in similar locations, shall be UL or ETL listed specifically for such use.
    d. Provide damp/wet location luminaires with a suitable IP rating for their planned environment, unless otherwise specified in Appendix – Luminaire Schedule.
        1) Luminaires located in bathtub and showers shall have a mimimum IP65 rating.

2.12 LUMINAIRE DESCRIPTIONS

A. General:

1. Provide luminaires which conform to the above standards and criteria, as indicated on the drawings, and as indicated below and in APPENDIX - Luminaire Schedule.
2. Verify mounting conditions and trim for all luminaire types.
3. Verify all voltages, and verify which luminaires require ducted or plenum air supply or return capability or are to be static.
4. Catalogue or series numbers, when shown herein, are intended to assist in establishing general type or category of luminaires. Provide a luminaire that meets the complete performance descriptions, as well as information provided by detail drawings. Standard catalogue cuts, when included, are for general assistance. Written luminaire descriptionsare the primary basis for luminaire specification. The Luminaire Schedule in the Appendix supersedes any legend or schedule on the Electrical Drawings.
5. The terminology "Or Approved Equal" if and only if used on the Luminaire Schedule, means the following: Products fabricated by alternative manufacturers to those listed may be submitted under the terms of the substitution clauses outlined in this Section. The products must meet the specifications in every way. Any substitutions or alternatives, may be accepted or rejected without a detailed explanation.
6. Provide timely and written notification of any discrepancies between drawing and specifications before submitting bids. If such discrepancies are not resolved prior to the end of the bid period, the more costly alternative will be considered as included in the bid price. See paragraph above regarding definition of Acceptable Manufacturers.
7. All finishes are to be factory applied, including colored flanges and trims.

B. Spare Parts / Extra Stock:

1. Provide spare parts and extra stock to the Owner upon completion of the work. Extra stock quantities shall be included in main order to prevent

additional cost to the Owner. All boxes shall be clearly labeled regarding contents, relevant luminaire type, and description. All spare parts shall be turned over to the Owner's authorized representative, and a receipt in duplicate, signed by the site representative shall be delivered to the Owner's authorized representative.

2. The following spare parts shall be provided as a minimum unless otherwise directed by Owner. Additional spare parts shall be provided as required by mention elsewhere in this specification, other sections of these Specifications, or the Contract Drawings:
    a. Sources/Lamps: Ten (10) percent (but not less than six (6) of each type)
    b. Cold Cathode Tubes: One (1) of each unique size, shape or color
    c. Ballasts/Transformers/ Power Supplies/LED Drivers: Five (5) percent (but not less than one (1) of each type)
    d. Lenses, Baffles, Snoots, Barndoors: Ten (10) percent (but not less than one (1) of each type
    e. UV Filters: Three (3) of each unique size or shape
    f. Color Filters: Three (3) of each unique size or shape
    g. Gobos/Pattern Templates: Two (2) of each
    h. Special Glass, Acrylic, Metal, Diffusers or Shapes for Types “XX”: Two (2) of each
    i. Spare Luminaires for Types “XX”: Two (2) of each
    j. Components for Luminaire Types “XX”: Two (2) of each
    k. Spare Remote Illuminator and Lamps for Type “XX”: One (1) spare illuminator and three (3) spare lamps/sources

C. LUMINAIRE SCHEDULE: SEE SECTION 26 51 13 APPENDIX LUMINAIRE SCHEDULE AT THE END OF THIS SECTION.

1. Complete specifications for the components (sources, power supplies, LED drivers, ballasts, reflectors, lenses, etc.) of luminaires described below are found above in Part 2. The Luminaire Schedule below supersedes any similar legend or schedule issued previously, or issued concurrently on the Drawings. Provide timely and written notification of any discrepancies before preparing any bids or proceeding with any work.
2. Descriptions for additional luminaire types, specified by the Electrical Engineer, may be located on the Electrical Drawings.

2.13 POLE/LUMINAIRE ASSEMBLIES

1. Supply luminaires, davit arms, brackets, poles, handhole covers, base components, and all other accessories complete by specified manufacturer who will be responsible for proper fitting of all elements.
2. Manufacturer will supply assembly to withstand 100 mph winds with a 1.3 gust factor without permanent deflection.
3. Manufacturer shall be responsible for design of and structural integrity of pole and complete base (i.e., concrete dimensions, rebar requirements, grounding and conduit requirements, drainage and ground compaction requirements under the specific installation conditions for the project).

PART 3 - EXECUTION

3.1 GENERAL

A. Install luminaires complete with light sources, as indicated, and with equipment, materials, parts, attachments, devices, aligner and filler clips, hardware, hangers, cables, supports, channels, frames and brackets necessary to make a safe, complete, and fully operative installation.

B. Verify and provide luminaires that are appropriate for the ceiling and mounting conditions of the project.

C. Coordinate with other trades as appropriate to properly interface installation of luminaires with other work.

D. Reject and do not install blemished, damaged, or unsatisfactory luminaires. Replace imperfect or unsatisfactory luminaires, if installed, as directed.

E. Set luminaires, when installed, to be true, and free of light leaks, warps, dents, or other irregularities. No light leaks are permitted at the ceiling line or from any visible part or joint of the luminaires. Install luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent luminaires, and secure in accordance with manufacturers' directions and approved shop drawings. Install all adjacent and continuous luminaires straight and trued, aligned in both plan and elevation. Supply and install alignment rods or joint straps as required to achieve this effect.

F. Provide finish for exposed parts or trims as specified. If not indicated, provide a finish as directed.

G. Do not install reflector cones, aperture plates, lenses, diffusers, louvers, and decorative elements of luminaires until completion of wet work, plastering, painting and general clean-up in the area of the luminaires.

H. Mount luminaires at heights and locations indicated on the Contract Drawings, or as required by Architect. Mounting heights specified or indicated are to be to the bottom of each luminaire for suspended and ceiling-mounted luminaires, and to the center of each luminaire for wall-mounted luminaires, unless otherwise noted. Obtain approval of the exact mounting for luminaires on the job before installation is commenced and, where applicable, after coordinating with the type, style, and pattern of the surface being installed.

I. Conform to the requirements of NFPA 70, and all other relevant codes. Supports shall be suitable for local seismic zone.

J. In Mechanical Equipment Rooms, luminaires shall be hung from ceilings after piping and equipment therein has been installed. Exact locations for such luminaires shall be determined at the job site during the course of the Work, in coordination with the mechanical work.

K. Adequately protect the housing of recessed luminaires during installation by internal blocking or framing to prevent distortion of sides, or dislocation of threaded lugs, which, upon completion, shall be in perfect alignment and match the corresponding holes in frames or rims. Holding screws shall be inserted freely without forcing, and shall remain easily removable for servicing.

L. Ground non-current-carrying parts of electrical equipment in accordance with UL and NEC provisions.

M. Upon completion of installation of luminaires, and after building circuits have been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at the site, then re-test to demonstrate compliance. Otherwise, remove and replace with new units, and proceed with re-testing. Coordinate all test times and requirements with the Architect or Construction Manager.

1. For normal and emergency building lighting, upon completion of the installation, conduct an operating test to show that the equipment operates in accordance with the requirements of this and other relevant sections.
2. Test all wiring with an insulation testing instrument, both before and after connection of luminaires and equipment. The minimum resistance shall be 250,000 ohms.

N. Upon completion of the installation, the luminaires and lighting equipment shall be in first class operating order and free from defects in condition and finish. At time of final inspection, all luminaires and equipment shall be clean, fully lamped, and be complete with required lenses or diffusers, reflectors, side panels, louvers, or other components necessary for the function of the luminaires. Any reflectors, lenses, diffusers, side panels or other parts damaged prior to the final inspection shall be replaced prior to inspection.

O. At the time of substantial completion and prior to field tests, replace lamps (excluding LED lamps and light engines) in interior luminaires which have been operating more than six months, or as work lights, or which are observed to be noticeably dimmed after use and testing during the construction period.

P. Luminaires and sources that are part of the Work of this section shall not be used for work lights during construction, except in Mechanical Equipment rooms. Provide adequate portable or temporary lighting for construction.

Q. Vibration Isolation: Mount and support all luminaires in such a manner to isolate the luminaire from structure-borne vibration, including but not limited to vibration caused by fans, motors, moveable tracks, moveable partitions, portable carts, vehicles, etc.

3.2 ACCESSIBILITY

A. Install equipment such as junction and pull boxes, luminaire housings, transformers, power supplies, ballasts, switches and controls, and other apparatus that shall be reached from time to time for operation and maintenance, to be easily accessible and appropriate for mounting and ceiling conditions.

3.3 SUPPORTS

A. Luminaires shall be securely fastened as per manufacturer's instructions. Provide plaster frames or mounting frames for luminaires that require them. Such frames shall be appropriate for the ceiling construction in which they are installed.

B. Provide necessary hardware with luminaires, such as stems, plates, plaster frames, hangers and similar items, for safe support of the luminaire. Provide plaster

frames made of non-ferrous metal, or of steel that has been suitably rustproofed after fabrication, as described above.

C. Provide supports for luminaires that are adequate to support the weight of the luminaires.

D. Provide hanging devices which, if visible from normal viewing angles, exactly match luminaire finishes specified, unless otherwise noted.

E. Where necessary to meet fire resistance requirements of Building Code authorities, provide enclosures housing recessed luminaires that are constructed to meet or exceed required fire resistance rating.

F. Provide attachment devices including brackets and cast metal shapes with the requisite rigidity and strength to maintain continuous alignment of installed luminaires. Attach luminaires to ceiling support members, and do not depend upon lathing, plaster or ceiling tile for alignment or support.

G. Provide luminaires mounted in suspended ceilings that are supported by saddle hangers or the bars attached to runners or between crossbars of ceiling systems. Provide mounting splines or other positive means of maintaining alignment and rigidity.

H. Provide supporting members that are surface passivated, and which are primed or paint-dipped to resist corrosion.

I. Provide fastening devices of a positive locking type, which do not require special tools to apply or remove them. Do not use tie wires in place of fastening devices.

J. Contractor is responsible for the necessary suspension system. Contractor shall ascertain the structural reliability of supports provided under other Sections of the specification.

K. Attach reflectors to housings by means of safety chains, which shall prevent reflectors from falling. No part of the chain may be visible after installation, when viewed from any angle up to 50 degrees from the vertical.

L. Provide pendant or surface mounted luminaires with required mounting devices and accessories, including hickeys, stud-extensions, ball aligners, canopies, and stems. Uniformly maintain the luminaire heights shown on the Contract Drawings or established in the field. The allowable tolerances in individual luminaire mounting shall not exceed 1/4 inch and may not vary more than 1/2 inch from the mounting height shown on the drawings. Install luminaires hung in continuous runs absolutely level, and in line with each other. Hanging devices shall comply with code requirements.

M. Provide an approved ceiling canopy for each stem, exactly matching specified finishes.

N. Place stems to be vertical and plumb.

O. Provide at least two rigid supports for individually mounted suspended linear luminaires. Where luminaires are ganged, provide supports at 8-0” intervals, unless otherwise indicated.

P. Recessed and semi-recessed luminaires:

1. Support rods or wires shall be provided with a minimum of four rods or wires per luminaire and located not more than 0’-6” from each corner of each luminaire.
2. Do not support luminaires by ceiling acoustical panels.
3. Where luminaires of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such luminaires independently or with at least 0’-2 ¾” metal channels spanning and wired to the ceiling tees.
4. Provide rods or wires for luminaire support under this section of the specifications.

3.4 AIMING AND ADJUSTMENT:

A. Provide labor and tools for final aiming, focusing and adjustment, under the Architect's and Lighting Consultant’s supervision, of all adjustable luminaires after regular working hours, and after dark in daylighted areas, whenever necessary, at no additional cost to the project. All luminaires shall be locked into place so that the aiming is not disturbed during future replacement of light source or power supply.

B. Request preliminary aiming diagrams during the shop drawing submittals. If aiming diagrams are provided, pre-aim those luminaires during installation or prior to final aiming.

C. If colored or diffusing filters are specified, supply up to four (4) theatrical gels for each luminaire type, in colors to be selected by the Architect after installation. Place alternate gels over the luminaires as requested.. When the final colors are selected, order the filters from the manufacturer, and install them. Note that the time between ordering and shipping may be approximately four weeks.

D. When extra lenses, louvers or shields are specified, change accessories until a final selection is made.

E. Note final aiming and locked positions, and include that information in the O&M manual.

3.5 CLEANING

A. Immediately prior to occupancy, clean reflector cones, reflectors, aperture plates, lenses, louvers, sources and decorative elements. As per manufacturer's instructions, de-staticize lenses after cleaning, installing them to leave no finger or dirt marks.

B. Upon completion of the luminaire installation and at the time of final inspection, luminaires shall be clean, and free from marks, dust, spotting or other defects. Replace any broken or defective parts prior to final inspection. Replace or make good all defects revealed by final inspection.

C. Protect installed luminaires from damage during the remainder of construction period.

3.6 COMMISSIONING

A. For any luminaire, power supply, LED driver, ballast, or lighting control system, provide a complete and operational system which meets or exceeds the performance specified.

B. The Owner shall provide for or engage an independent commissioning agent to verify that all components and system as a whole meets design intent and to evaluate the Contractor's work. This includes evaluation and verification of all adjustable features, such as aiming angles, time clock settings, sensitivity settings, high end trim, fine tuning, customized settings, etc. Provide labor and equipment after normal working hours to correct and adjust system, working with or without direct supervision of commissioning agent until reasonable satisfaction has been achieved.

C. Provide Spares, as described in Part 2 above.

D. Submit a maintenance manual and operational submittals, as called for in Part 1 above, and under the conditions of the relevant General Requirements. After submittal is reviewed, make changes and resubmit, if necessary. After review and approval , this manual will be kept on site for reference use by facility maintenance personnel.

E. Assemble and submit, in bound 8.5in x 11in format, an Operation and Maintenance Manual that includes the following:

1. A chart clearly documenting the luminaire, source, power supply, LED driver and/or ballast actually installed for each luminaire type, with product designations sufficient for reordering new product and components to match those installed.
    a. For Digital Addressable Fixtures: A chart clearly documenting luminaire type, Make/Model, location, digital address, control address, for client operation and for future maintenance.
2. A current list of lighting distributors, manufacturers and manufacturer's representatives, (for the purposes of replacement, reordering or trouble-shooting). This list shall be keyed to the list of luminaires, sources, power supplies, LED drivers and ballasts, so that the Owner has a name, address and phone number of at least two (2) contacts for each product or component.
3. Shop drawings, technical data sheets, product technical documents, installation instructions, cut sheets, operating instructions, calibration instructions, and troubleshooting guides in the installation, including but not limited to sources, power supplies, LED drivers, ballasts and lighting control devices.
4. Color-coded as-built drawings showing all source, power supply, LED drivers and ballast types, to facilitate replacement. O&M Walk-through: Transfer of the O&M document will include a thorough walk-through and demonstration of equipment by Contractor for facility personnel.

F. Owner Training: At the Owner's convenience, provide a minimum of four (4) hours, not to exceed eight (8) hours, of expertise and training concerning the installation, characteristics, operations and maintenance of the Work of this Section. Such training shall take place after the Owner has been provided the final approved maintenance and operational submittals mentioned above.

G. Video-tape the training session, and provide two (2) copies on flash/thumb drives, or DVD. Alternative electronic formats may be provided if mutually agreed upon.

PART 4 - APPENDICES

4.1 GENERAL

A. The appendices listed below are integral parts of the specifications and contract documents. If either Appendix is missing or incomplete, provide timely and written notification. Do not submit a bid based on incomplete information.

4.2 APPENDIX – LUMINAIRE SCHEDULE

A. See Part 2 above for complete specifications for the components (sources, power supplies, LED drivers, ballasts, reflectors, lenses, etc.) of the luminaires described in the Schedule. The Luminaire Schedule below supersedes any similar legend or schedule issued previously, or issued concurrently on the drawings. Provide timely and written notification of any discrepancies before preparing any bids or proceeding with any work.

4.3 APPENDIX – LIGHT FIXTURE CUTSHEETS

A. Contractor shall provide luminaires that meet the complete performance descriptions in Part 2 and the Appendix above, along with luminaire detail drawings and sketches. If there are any discrepancies between luminaire descriptions, catalogue numbers, sketches, or catalogue cuts that are unresolved during the bid period, the more costly option will be considered as included in the bid prices. The information in standard catalogue extracts are for general information only, and the product provided must meet all criteria described in the Luminaire Schedule and in this specification section above.

4.4 APPENDIX – LIGHTING CONTROL INTENT NARRATIVE

A. Contractor shall provide the lighting control system to meet the complete performance descriptions in this Appendix. Provide Manufacturer's written confirmation that the performance of the control intent **narrative** has been met or provide sequence of operation for all spaces described in this Appendix during the submittal process. If there are any discrepancies between the performance of the submitted system and the specified system identify these differences and why the specified performance cannot be met.

4.5 APPENDIX – LIGHTING CONTROL INTENT DIAGRAM

A. Contractor shall provide the lighting control system to meet the complete performance descriptions in this Appendix. Provide Manufacturer's written confirmation that the performance of the control intent diagram has been met or provide sequence of operation for all spaces described in this Appendix during the submittal process. If there are any discrepancies between the performance of the

submitted system and the specified system identify these differences and why the specified performance cannot be met.

End of Section 26 51 13

APPENDIX – LUMINAIRE SCHEDULE

Luminaire Schedule

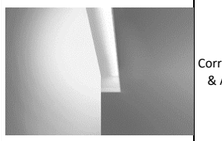
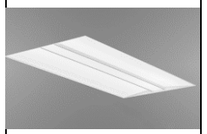
GENERAL NOTES:
- Provide luminaire shop drawings for Lighting Consultant, Architect, and Owner approval prior to fabrication. For all continuous run luminaires, including track, manufacturer shall submit a layout drawing for run lengths specified on architectural drawings during submittal review for Lighting Designer and Architect approval prior to fabrication.
- Architect shall verify all luminaire body, trim, flange, pole, track and any other visible accessories/hardware finishes. All visible conduit, junction boxes, canopy plates, hardware, gear containers, etc. shall be painted to match adjacent surfaces (Architect to verify).
- Refer to electrical drawings for voltage information. Electrical contractor shall verify all voltages with Electrical Engineer before placing any orders or proceeding with any work.
- Electrical contractor shall verify emergency operation of all luminaires with Electrical Engineer before placing any orders or proceeding with any work. Refer to electrical drawings for all emergency or code-related requirements.
- Contractor shall verify and coordinate recessed luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including grid type and flange requirements such that there are no light leaks between luminaire and ceiling system and luminaire can accommodate ceiling thickness.
- Contractor to verify and coordinate all other luminaire installation and mounting with architectural details and field conditions.
- Contractor shall verify mounting details with architect and/or architectural drawings and order all mounting components necessary for installation of luminaire at no additional cost, even if such components are not specifically called for in the contract documents.
- Provide adequate and sturdy support for each luminaire. Contractor shall be responsible for verifying weight and mounting method of all luminaires and furnish and install suitable supports. Luminaire mounting assemblies shall comply with all local seismic codes and regulations.
- Provide all luminaires as shown complete with all light sources, completely wired, controlled and securely attached to supports.
- Where both narrative and/or pictorial luminaire descriptions are provided, the written description shall take precedence and prevail. Contractor to confirm via RFI process with lighting designer and architect.
- Locations of luminaires are shown diagrammatically. Verify exact location and spacing with architectural drawings and designer at the site during installation. Notify Owner about field conditions at variance with Contract Documents before commencing installation.
- At the completion of construction, clean lenses and reflectors of all luminaires so as to render them free of any material, substance or film foreign to the luminaire. Blemished, damaged, or unsatisfactory luminaires shall be replaced in a satisfactory manner.

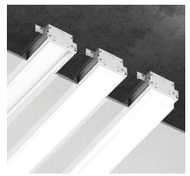
- When applicable, contractor shall review existing circuiting, verify new loads and panel capacity. Contractor shall notify Owner if a conflict between design documents and field conditions occur.
- Contractor shall refer to electrical drawings for information on controls and dimming requirements, and coordinate luminaire and control accessories required for a fully functioning system.
- Contractor to provide line item pricing at bid phase or earlier as requested by lighting designer or architect per type with labor and installation shown as separate line items.
- All 0-10V dimming gear provided shall be isolated to avoid AC interface on the dimming line.
- All LED sources within the same luminaire Type shall be within two (2) MacAdam ellipses/steps of each other.
- For all adjustable luminaires provide labor and materials for final aiming and locking of all adjustable luminaires under the Architect's supervision. Aiming shall take place immediately before building is turned over to Owner, after regular working hours where required. Contractor shall coordinate necessary personnel and equipment
- All luminaires shall have a minimum 3-year warranty.
- All lighting systems shall be ordered with necessary gear, power feeds and mounting accessories as required for installation of a complete system.
- Locate remote gear in a secure, concealed, accessible and well-ventilated location in compliance with manufacturer's directions.
- All luminaires and workmanship shall be guaranteed free of defects and fully operational for a minimum of one year after the acceptance of the project by the Owner unless otherwise indicated in the specifications. Any luminaires or workmanship found to be defective during the warranty period shall either be fixed or replaced by the Contractor at no cost to the Owner.
- The luminaires and workmanship must be in accordance with and meet the standards and regulations of the following: Underwriters Laboratories, National Electric Code, & Local Building and Life Safety Code Agencies.
- Replace all burned-out or inoperative sources and gear in all luminaires before the building is accepted by the Owner so that all luminaires will be in first class operating condition.
- For pendant mounted luminaires provide adequate cord length to suspend luminaires at heights shown on architectural drawings or indicated in the lighting fixture schedule.
- Electrical contractor shall field-verify each run length of continuous fixtures prior to ordering.
- Provide luminaire samples per type as requested in the Fixture Schedule. Supply a completely operable luminaire with cord and plug for standard 120 Volt service.
- Code required accessories and controls such as but not limited to motion sensors, photocell controls, dimming controls, etc. to be specified and coordinated by Electrical Engineer.

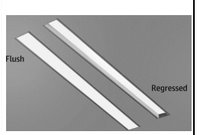
TYPE	APPLICATION IMAGE	LOCATION	DESCRIPTION	LAMPS/SOURCE	POWER SUPPLY/ DRIVER	INPUT WATTS	INPUT WATT UNITS	LISTING	MANUFACTURER	ALT	NOTES
INTERIOR LUMINAIRES											
F1		Throughout	Recessed aperture LED downlight with galvanized steel housing, medium beam spread, polycarbonate lens, matte diffuse reflector finish. . Dimensions: Fixture: 4.5" Dia. Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 1001 Lumens	Integral DIM (10% Dimming) 0-10V	8.8W	EA	UL Listed	GOTHAM LIGHTING EVO 4" #EVO4-30-10-REFLECTOR -MD-LD-MVOLT-GZ10	LIGHTOLIER "CALCULITE 4" LED DOWNLIGHT"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements.
F1A	**NOT USED**	FIXTURE NOT USED									
F1B		Bathroom	Recessed aperture LED downlight with galvanized steel housing, solite lens, matte diffuse reflector finish. . Dimensions: Fixture: 4.5" Dia. Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 843 Lumens	Integral DIM (10% Dimming) 0-10V	8.8W	EA	UL Listed	GOTHAM LIGHTING EVO 4" #EVO4SH-30-10-DFR-TRIM FINISH-SOL-MVOLT-EZ10	LIGHTOLIER "CALCULITE 4" LED DOWNLIGHT"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements. 4. Fixture shall be labeled "suitable for wet locations".

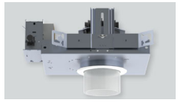
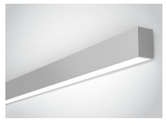
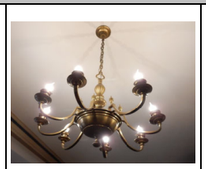
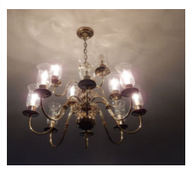
TYPE	APPLICATION IMAGE	LOCATION	DESCRIPTION	LAMPS/SOURCE	POWER SUPPLY/ DRIVER	INPUT WATTS	INPUT WATT UNITS	LISTING	MANUFACTURER	ALT	NOTES
F1C		Apartment Unit	Recessed aperture LED downlight with galvanized steel housing, medium wide beam spread, polycarbonate lens, matte diffuse reflector finish. . Dimensions: Fixture: 4.5" Dia. Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 573 Lumens	Integral DIM (10% Dimming) 0-10V	7.2W	EA	UL Listed	GOTHAM LIGHTING EVO 4" #EVO4-30-05-REFLECTOR -MWD-LD-MVOLT-GZ10	LIGHTOLIER "CALCULITE 4" LED DOWNLIGHT"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements.
F1D	**NOT USED**	FIXTURE NOT USED									
F2	**NOT USED**	FIXTURE NOT USED									
F2A	**NOT USED**	FIXTURE NOT USED									
F3		Lounge, Double Bedroom & Stairs	Surface mounted LED downlight with cold rolled formed steel housing, frosted white acrylic drum, and powder coat finish. Dimensions: Fixture: 36" Diameter x 5" Tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 4755 Lumens	Integral DIM 0-10V	60.0W	EA	UL Listed	SPI LIGHTING Novato Drum #L100W*MOD 40% DECREASE OUTPUT-120-277V-3000K-H05-FB00	PINNACLE LIGHTING "FINA F36D"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Luminaire shall be mounted over a surface-mounted junction box (by electrician). 4. Fixture shall be provided with modified 40% decrease output. 5. Fixture alternate shall meet shallow housing requirement of 5" height max. housing and 5 year minimum waranty.
F3A		Lounge & Stairs	Surface mounted LED downlight with cold rolled formed steel housing, frosted white acrylic drum, and powder coat finish. Dimensions: Fixture: 36" Diameter x 5" Tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 2380 Lumens	Integral DIM 0-10V	30.0W	EA	UL Listed	SPI LIGHTING Novato Drum #L100W*MOD 70% DECREASE OUTPUT-120-277V-3000K-H05-FB00	PINNACLE LIGHTING "FINA F36D"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Luminaire shall be mounted over a surface-mounted junction box (by electrician). 4. Fixture shall be provided with modified 70% decrease output. 5. Fixture alternate shall meet shallow housing requirement of 5" height max. housing and 5 year minimum waranty.

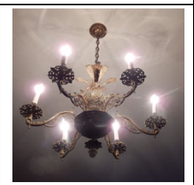
TYPE	APPLICATION IMAGE	LOCATION	DESCRIPTION	LAMPS/SOURCE	POWER SUPPLY/ DRIVER	INPUT WATTS	INPUT WATT UNITS	LISTING	MANUFACTURER	ALT	NOTES
F3B		Single Bedroom	Surface mounted LED downlight with cold rolled formed steel housing, frosted white acrylic drum, and powder coat finish. Dimensions: Fixture: 24" Diameter x 5" Tall Warranty: 5 Years	LED 3000K 90+ CRI L70 @ 60,000 Hours 3570 Lumens	Integral DIM 0-10V	45.0W	EA	UL Listed	SPI LIGHTING Novato Drum #L45W-120-277V-3000K-H05-FB02	PINNACLE LIGHTING "FINA F24D"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Luminaire shall be mounted over a surface-mounted junction box (by electrician). 4. Fixture alternate shall meet shallow housing requirement of 5" height max. housing and 5 year minimum waranty.
F4	**NOT USED**	FIXTURE NOT USED									
F5	**NOT USED**	FIXTURE NOT USED									
F6		Throughout	Recessed aperture LED accent light with galvanized steel housing, 40º vertical tilt, 365º horizontal tilt, field interchangeable optics, 35º beam spread, and matte-diffuse reflector finish. Dimensions: Fixture: 4.5"Diameter Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 1359 Lumens	Integral DIM (10% Dimming) 0-10V	15.1W	EA	UL Listed	GOTHAM LIGHTING Incito 4" #ICO4ADJ-30-15-REFLECTOR-T30-LD-35D-120-GZ10		1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements. 4. Fixture shall be aimed towards the wall. 5.Fixture requires aiming to be determined in the field. Provide all accessories as noted, final accessories shall be determined in the field. Any unused accessories shall be provided to the Owner for extra stock.
F6A	**NOT USED**	FIXTURE NOT USED									
F7		Dorm. Doors	Wall mounted LED sconce with precision-machined aluminum body, frosted glass diffuser, frosted acrylic shade, and black painted finish. Dimensions: Fixture: 6" wide x 7" tall x 1-1/2" deep Warranty: 5 Years	LED 3000K 90+ CRI L70 @ 50,000 Hours 275 Lumens	Remote DIM (10% Dimming) ELV	7.0W	EA	UL Listed	Kuzco Lighting Guide #WS33407-BK + ELV Dimming Driver as required	ARTEMIDE "PIANO WALL DIRECT/INDIRECT"	1. Fixture shall dim. 2. Refer to architectural drawings for mounting height AFF. Luminaire shall be mounted over a recessed junction box (by electrician). 3. Architect shall verify fixture finish. 4. Electrical Engineer/Contractor to verify compatibility of light source, gear and dimming system.

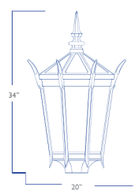
TYPE	APPLICATION IMAGE	LOCATION	DESCRIPTION	LAMPS/SOURCE	POWER SUPPLY/ DRIVER	INPUT WATTS	INPUT WATT UNITS	LISTING	MANUFACTURER	ALT	NOTES
F8		Corridors, Lounge & Apartament Units	Recessed linear LED perimeter lighting with extruded aluminum housing, natural aluminum housing finish, regressed extruded acrylic lens, and matte white fascia finish. Dimensions: Fixture: 4-1/8" wide x 6-3/4" tall Warranty: 5 Years	LED 3000K 90 CRI L80 @ 60,000 Hours 632 Lumens/FT	Integral DIM (1% Dimming) 0-10V	5.8W	LFT	UL Listed	MARK LIGHTING SPR LED Perimeter #SPRLED-LOP-LENGTH-RLP-CEILING TRIM-80CRI-30K-600LMF-MIN1-MVOLT-ZT	PINNACLE "EDGE EVL"	1. Fixture shall dim. 2. Luminaire is a perimeter luminaire to be installed before ceiling, Contractor shall coordinate installation sequence as required. 3. Fixtures shall be installed in a continuous wall-to-wall installation for fixtures that end against walls. Fixtures that do not end against walls shall run the full length of the wall being illuminated. Provide corners, extensions/telescoping sleeves and end caps as required for installation of a complete system. Center illuminated portion of luminaire in wall.
F8A	**NOT USED**	FIXTURE NOT USED									
F9		Laundry Room	Recessed LED troffer downlight with cold rolled steel housing, extruded aluminum door frame, cold rolled steel end caps, highly reflective white precision formed reflector, soft white acrylic side and center panels, and powder coat finish. Dimensions: Fixture: 2'-0" Width x 4'-0" Length Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 61,000 Hours 4076 Lumens	Integral DIM (10% Dimming) 0-10V	33.8W	EA	UL Listed	MARK LIGHTING Whisper LED Troffer #WHSPR-2X4-4000LM-30K-80CRI-MIN10-ZT-MVOLT-SWC	PINNACLE "LUCEN LU24"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements.
F10		Historical Lounge	Recessed LED retrofit downlight with galvanized steel housing, field interchangeable optics, 50º beam spread, and matte-diffuse reflector finish. Dimensions: Fixture: 4-5/16" Dia. x 8" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 2500 Lumens	Integral DIM (10% Dimming) 0-10V	33.0W	EA	UL Listed	GOTHAM LIGHTING Incito 4" #ICOI-30-25-TRIM-LD-50D-MVOLT-EZ10-MEZREMODELHOUSING	INTENSE LIGHTING "GDS4DR / IRDS400"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements. 4. Fixture shall be modified to remodel housing.
F10A		Historical Lounge	Recessed LED retrofit downlight with galvanized steel housing, field interchangeable optics, 50º beam spread, and matte-diffuse reflector finish. Dimensions: Fixture: 4-5/16" Dia. x 8" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 3000 Lumens	Integral DIM (10% Dimming) 0-10V	36.0W	EA	UL Listed	GOTHAM LIGHTING Incito 4" #ICOI-30-30-TRIM-LD-50D-MVOLT-EZ10-MEZREMODELHOUSING	INTENSE LIGHTING "GDS4DR / IRDS400"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements. 4. Fixture shall be modified to remodel housing.
F10B		Historical Lounge	Recessed LED retrofit downlight with galvanized steel housing, field interchangeable optics, 50º beam spread, and matte-diffuse reflector finish. Dimensions: Fixture: 4-5/16" Dia. x 8" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 3500 Lumens	Integral DIM (10% Dimming) 0-10V	39.0W	EA	UL Listed	GOTHAM LIGHTING Incito 4" #ICOI-30-35-TRIM-LD-50D-MVOLT-EZ10-MEZREMODELHOUSING	INTENSE LIGHTING "GDS4DR / IRDS400"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements. 4. Fixture shall be modified to remodel housing.

TYPE	APPLICATION IMAGE	LOCATION	DESCRIPTION	LAMPS/SOURCE	POWER SUPPLY/ DRIVER	INPUT WATTS	INPUT WATT UNITS	LISTING	MANUFACTURER	ALT	NOTES
F11		Music Room	Recessed linear LED downlight with cold-rolled steel housing, extruded aluminum ceiling trim, precision formed steel reflector, 90% transmissive acrylic lens, and powder coat finish. Dimensions: Fixture: 4" Width x 4-3/8" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 500 Lms/FT	Integral DIM (10% Dimming) 0-10V	7.2W	LFT	UL Listed	MARK LIGHTING Slot 4 LED #SL4L-LOP-LENGTH-FLP-CEILING TRIM-80CRI-30K-500LMF-MIN10-120-FINISH-ZT	PINNACLE "EDGE EV4D"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements.
F12	**NOT USED**	FIXTURE NOT USED									
F13		Historical Lounge	Recessed LED retrofit adjustable downlight with galvanized steel housing, 30º vertical tilt, 355º horizontal tilt, field interchangeable optics, 35º beam spread, and matte-diffuse reflector finish. Dimensions: Fixture: 4-5/16" Dia. x 10" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 1500 Lumens	Integral DIM (10% Dimming) 0-10V	17.0W	EA	UL Listed	GOTHAM LIGHTING Incito 4" Adjustable #ICOIADJ-30-15-REFLECTOR-LD-35D-120-EZ10-MEZREMODELHOUSING	INTENSE LIGHTING "GD4AR / IRA400"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements. 4. Fixture shall be aimed towards the wall. 5.Fixture requires aiming to be determined in the field. Provide all accessories as noted, final accessories shall be determined in the field. Any unused accessories shall be provided to the Owner for extra stock. 6. Fixture shall be modified to remodel housing.
F13A	**NOT USED**	FIXTURE NOT USED									
F14	**NOT USED**	FIXTURE NOT USED									
F15	**NOT USED**	FIXTURE NOT USED									

TYPE	APPLICATION IMAGE	LOCATION	DESCRIPTION	LAMPS/SOURCE	POWER SUPPLY/ DRIVER	INPUT WATTS	INPUT WATT UNITS	LISTING	MANUFACTURER	ALT	NOTES
F16		Typical Kitchen	Wall mounted LED linear downlight with extruded aluminum housing, white formed steel reflector, co-extruded 90% transmissive acrylic lens, and silver gloss finish. Dimensions: Fixture: 2-1/2" Width x 3-3/4" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 500 Lms/FT	Integral DIM (10% Dimming) 0-10V	4.6W	LFT	UL Listed	MARK LIGHTING Slot 2 LED Wall #S2LWD-LLP-LENGTH-80CRI-30K-500LMF-MIN1-MVOLT-FINISH-ZT	PINNACLE "EDGE EX2D"	1. Fixture shall dim. 2. Refer to architectural drawings for mounting height AFF. Luminaire shall be mounted over a recessed junction box (by electrician).
F16A	**NOT USED**	FIXTURE NOT USED									
F17		Stairs	Recessed round LED downlight with with galvanized steel housing, self-flanged die cast aluminum bevel, 65º beam distribution, 1" regressed lens, integral solite lens, and painted finish. Dimensions: Fixture: 3" Width x 2" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 1425 Lumens	Integral DIM (1% Dimming) 0-10V	15.0W	EA	UL Listed	USAI Beveled Mini Shallow Housing #B3RDF-15X3-30KS-65-S-TRIM FINISH-FLANGE FINISH-FT-UNV-D22	BY MEETING PERFORMANCE AND AESTHETIC SPECIFICATION	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements. 4. Fixture alternate shall meet shallow housing requirement of 2-1/2" height max. housing.
F18		Stairs	Recessed round LED adjustable accent light with galvanized steel housing, self-flanged die cast aluminum bevel, 50º beam spread, 40º vertical tilt, 362º horizontal tilt, integral solite lens, and painted finish. Dimensions: Fixture: 3" Width x 4" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 2475 Lumens	Integral DIM (1% Dimming) 0-10V	20.0W	EA	UL Listed	USAI Beveled Mini Adjustable Shallow Housing #B3RAF-25-20X3-30KS-50-S-TRIM FINISH-FLANGE FINISH-FTA-UNV-D22	BY MEETING PERFORMANCE AND AESTHETIC SPECIFICATION	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements. 4. Fixture alternate shall meet shallow housing requirement of 4" height max. housing.
F19		Typical Kitchen	Recessed linear LED wallwasher with cold-rolled steel housing, extruded aluminum ceiling trim, precision formed steel reflector, 90% transmissive acrylic lens, and powder coat finish. Dimensions: Fixture: 4" Width x 4-3/8" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 500 Lms/FT	Integral DIM (10% Dimming) 0-10V	7.2W	LFT	UL Listed	MARK LIGHTING Slot 4 LED #SL4L-LOP-LENGTH-FLP-CEILING TRIM-80CRI-30K-500LMF-WW-MIN10-120-FINISH-ZT	PINNACLE "EDGE EV4D"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements.

TYPE	APPLICATION IMAGE	LOCATION	DESCRIPTION	LAMPS/SOURCE	POWER SUPPLY/ DRIVER	INPUT WATTS	INPUT WATT UNITS	LISTING	MANUFACTURER	ALT	NOTES
F20		Level 4 & 5 Corridor	Recessed round LED downlight with decorative frosted acrylic, galvanized steel housing, self-flangedaluminum spun, soft etched cast machined acrylic, 50º beam distribution, integral solite lens, and painted finish. Dimensions: Fixture: 4" aperture x 4.9" tall Decorative Dropped Lens: 4" dia. x 4" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 1148 Lumens	Integral DIM (10% Dimming) 0-10V	23.7W	EA	UL Listed	SPECTRUM LIGHTING Illumitech Decorative #RDFO4XT-20L-30K-XW-DS10-VOLTS (Housing) + #RD4FXTMWSO-FA-CY4 (Trim)	LOUIS POULSEN "AH MINI"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements. 4. Alternates by meeting aesthetic and performance specification.
F21		Bathroom	Wall mounted LED linear downlight with extruded aluminum housing, white formed steel reflector, co-extruded 90% transmissive acrylic lens, and silver gloss finish. Dimensions: Fixture: 1-1/2" Width x 2-5/16" tall Warranty: 5 Years	LED 3000K 90+ CRI L70 @ 50,000 Hours 240 Lms/FT	Integral DIM (10% Dimming) 0-10V	2.0W	LFT	UL Listed	MARK LIGHTING Slot 1 LED Wall ##S1LWD-LLP-LENGTH-90CRI-30K-200LMF-MIN1-MVOLT-FINISH-ZT	PINNACLE LIGHTING "EDGE EX12"	1. Fixture shall dim. 2. Refer to architectural drawings for mounting height AFF. Luminaire shall be mounted over a recessed junction box (by electrician). 3. Fixture alternate shall meet shallow extrusion body profile of no more than 1-1/2" wide x 2-1/2" height.
F22		Stairs	Surface mounted round LED downlight with 4" octagonal junction box, die cast aluminum body, 50º beam distribution, integral solite lens, and painted finish. Dimensions: Fixture: 5-13/16" Width x 6-11/16" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 1725 Lumens	Integral DIM (10% Dimming) 0-10V	16.0W	EA	UL Listed	USAI BeveLED Block #BLRD5-16C3-30KS-50-S-FINISH-CC-UNV-D2 (Fixture) + #KAR-KEY ACCESSORY-FINISH (Conduit Cutout Keys)	LUCIFER "CY2"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate all other luminaire installation, mounting and conduit entry with architectural details and field conditions. Contractor shall order all mounting components necessary for installation of luminaire. 4. Fixture alternate shall meet shallow body requirement of 7" height max. body and conduit cutout mounting.
DECORATIVE LUMINAIRES											
D1		Historical Lounge 2122	Suspended existing luminaire. Lamp: E26 Medium screw base candelabra LED lamp with frosted glass, and B10 shape. Lamp Warranty: 3 Years	LED RETROFIT 2700K 83 CRI L70 @ 250,000 Hours 450 Lumens	Integral DIM Line Voltage	4.5W	EA	UL Listed	GRAND LIGHT CHANDELIER RESTORAURATION ARCHIPELAGO LIGHTING #LTB10F50027MB (QTY.: 8)	EXISTING FIXTURE TO BE REFURBISHED	1. Existing luminaires from site shall be refurbished. Luminaires shall be removed from location and carefully packaged for shipment to fabricator. Luminaire shall be repaired, refurbished and rewired. Provide new lamp sockets and wiring. All metal work, finishes and glass replacement parts are to be in keeping with the original style and effect of the luminaire. Contractor shall re-install luminaire. 2. Contractor shall verify lamp quantity prior to ordering. 3. Fixture shall dim.
D1A		Historical Lounge	Suspended existing luminaire. Lamp: E26 Medium screw base candelabra LED lamp with frosted glass, and B10 shape. Lamp Warranty: 3 Years	LED RETROFIT 2700K 83 CRI L70 @ 250,000 Hours 450 Lumens	Integral DIM Line Voltage	4.5W	EA	UL Listed	GRAND LIGHT CHANDELIER RESTORAURATION ARCHIPELAGO LIGHTING #LTB10F50027MB (QTY.: 12)	EXISTING FIXTURE TO BE REFURBISHED	1. Existing luminaires from site shall be refurbished. Luminaires shall be removed from location and carefully packaged for shipment to fabricator. Luminaire shall be repaired, refurbished and rewired. Provide new lamp sockets and wiring. All metal work, finishes and glass replacement parts are to be in keeping with the original style and effect of the luminaire. Contractor shall re-install luminaire. 2. Contractor shall verify lamp quantity prior to ordering. 3. Fixture shall dim.

TYPE	APPLICATION IMAGE	LOCATION	DESCRIPTION	LAMPS/SOURCE	POWER SUPPLY/ DRIVER	INPUT WATTS	INPUT WATT UNITS	LISTING	MANUFACTURER	ALT	NOTES
D1B		Historical Lounge	Suspended existing luminaire. Lamp: E26 Medium screw base candelabra LED lamp with frosted glass, and B10 shape. Lamp Warranty: 3 Years	LED RETROFIT 2700K 83 CRI L70 @ 250,000 Hours 450 Lumens	Integral DIM Line Voltage	4.5W	EA	UL Listed	GRAND LIGHT CHANDELIER RESTORAURATION ARCHIPELAGO LIGHTING #LTB10F50027MB (QTY.: 6)	EXISTING FIXTURE TO BE REFURBISHED	1. Existing luminaires from site shall be refurbished. Luminaires shall be removed from location and carefully packaged for shipment to fabricator. Luminaire shall be repaired, refurbished and rewired. Provide new lamp sockets and wiring. All metal work, finishes and glass replacement parts are to be in keeping with the original style and effect of the luminaire. Contractor shall re-install luminaire. 2. Contractor shall verify lamp quantity prior to ordering. 3. Fixture shall dim.
D1C		Historical Lounge 3308	Suspended existing luminaire. Lamp: E26 Medium screw base candelabra LED lamp with frosted glass, and B10 shape. Lamp Warranty: 3 Years	LED RETROFIT 2700K 83 CRI L70 @ 250,000 Hours 450 Lumens	Integral DIM Line Voltage	4.5W	EA	UL Listed	GRAND LIGHT CHANDELIER RESTORAURATION ARCHIPELAGO LIGHTING #LTB10F50027MB (QTY.: 12)	EXISTING FIXTURE TO BE REFURBISHED	1. Existing luminaires from site shall be refurbished. Luminaires shall be removed from location and carefully packaged for shipment to fabricator. Luminaire shall be repaired, refurbished and rewired. Provide new lamp sockets and wiring. All metal work, finishes and glass replacement parts are to be in keeping with the original style and effect of the luminaire. Contractor shall re-install luminaire. 2. Contractor shall verify lamp quantity prior to ordering. 3. Fixture shall dim.
D1D		Historical Lounge 3264	Suspended existing luminaire. Lamp: E26 Medium screw base candelabra LED lamp with frosted glass, and B10 shape. Lamp Warranty: 3 Years	LED RETROFIT 2700K 83 CRI L70 @ 250,000 Hours 450 Lumens	Integral DIM Line Voltage	4.5W	EA	UL Listed	GRAND LIGHT CHANDELIER RESTORAURATION ARCHIPELAGO LIGHTING #LTB10F50027MB (QTY.: 6)	EXISTING FIXTURE TO BE REFURBISHED	1. Existing luminaires from site shall be refurbished. Luminaires shall be removed from location and carefully packaged for shipment to fabricator. Luminaire shall be repaired, refurbished and rewired. Provide new lamp sockets and wiring. All metal work, finishes and glass replacement parts are to be in keeping with the original style and effect of the luminaire. Contractor shall re-install luminaire. 2. Contractor shall verify lamp quantity prior to ordering. 3. Fixture shall dim.
D2		Corridor Lounge	Surface mounted existing schoolhouse luminaire. Lamp: E26 Medium screw base LED lamp with frosted glass, and A19 shape. Lamp Warranty: 3 Years	LED 3000K 83 CRI L70 @ 250,000 Hours 800 Lumens	Integral DIM Line Voltage	7.5W	EA	UL Listed	GRAND LIGHT SCHOOLHOUSE RESTORAURATION ARCHIPELAGO LIGHTING #LTA19F80030MB (QTY.: 1)	EXISTING FIXTURE TO BE REFURBISHED	1. Existing luminaires from site shall be refurbished. Luminaires shall be removed from location and carefully packaged for shipment to fabricator. Luminaire shall be repaired, refurbished and rewired. Provide new lamp sockets and wiring. All metal work, finishes and glass replacement parts are to be in keeping with the original style and effect of the luminaire. Contractor shall re-install luminaire. 2. Contractor shall verify lamp quantity prior to ordering. 3. Fixture shall dim.
D3	**NOT USED**	FIXTURE NOT USED									
D4		Open Stairs	Wall mounted square LED sconce with steel frame, extruded aluminum heatsink, cylindrical white opal glass diffuser, and black painted finish. Dimensions: Fixture: 3-5/8" wide x 21" tall x 3-1/2" deep Warranty: 5 Years	LED 3000K 90+ CRI L70 @ 50,000 Hours 1180 Lumens	Remote DIM (10% Dimming) ELV	21.0W	EA	UL Listed	Kuzco Lighting Lochwood #WS83421-BK + ELV Dimming Driver as required	BY MEETING PERFORMANCE AND AESTHETIC SPECIFICATION & ADA COMPLIANCE.	1. Fixture shall dim. 2. Refer to architectural drawings for mounting height AFF. Luminaire shall be mounted over a recessed junction box (by electrician). 3. Architect shall verify fixture finish. 4. Electrical Engineer/Contractor to verify compatibility of light source, gear and dimming system.
D5		Vestibule 20040 & 20050	Suspended existing luminaire. Lamp: E26 Medium screw base LED lamp with frosted glass, and A19 shape. Lamp Warranty: 3 Years	LED RETROFIT 3000K 83 CRI L70 @ 250,000 Hours 800 Lumens	Integral DIM Line Voltage	7.5W	EA	UL Listed	GRAND LIGHT CHANDELIER RESTORAURATION ARCHIPELAGO LIGHTING #LTA19F80030MB (QTY.: 3)	EXISTING FIXTURE TO BE REFURBISHED	1. Existing luminaires from site shall be refurbished. Luminaires shall be removed from location and carefully packaged for shipment to fabricator. Luminaire shall be repaired, refurbished and rewired. Provide new lamp sockets and wiring. All metal work, finishes and glass replacement parts are to be in keeping with the original style and effect of the luminaire. Contractor shall re-install luminaire. 2. Contractor shall verify lamp quantity prior to ordering. 3. Fixture shall dim.

TYPE	APPLICATION IMAGE	LOCATION	DESCRIPTION	LAMPS/SOURCE	POWER SUPPLY/ DRIVER	INPUT WATTS	INPUT WATT UNITS	LISTING	MANUFACTURER	ALT	NOTES
D5A		Corridor Lounge 30057	Suspended existing luminaire. Lamp: E26 Medium screw base candelabra LED lamp with frosted glass, and B10 shape. Lamp Warranty: 3 Years	LED RETROFIT 2700K 83 CRI L70 @ 250,000 Hours 450 Lumens	Integral DIM Line Voltage	4.5W	EA	UL Listed	GRAND LIGHT CHANDELIER RESTORAURATION ARCHIPELAGO LIGHTING #LTB10F50027MB (QTY.: 7)	EXISTING FIXTURE TO BE REFURBISHED	1. Existing luminaires from site shall be refurbished. Luminaires shall be removed from location and carefully packaged for shipment to fabricator. Luminaire shall be repaired, refurbished and rewired. Provide new lamp sockets and wiring. All metal work, finishes and glass replacement parts are to be in keeping with the original style and effect of the luminaire. Contractor shall re-install luminaire. 2. Contractor shall verify lamp quantity prior to ordering. 3. Fixture shall dim.
D6		Vestibule	Wall mounted LED sconce with aged iron frame, and opal diffuser. Dimensions: Fixture: 4.75" wide x 16.5" tall Fixture Warranty: 3 Years Lamp Warranty: 3 Years	LED RETROFIT 2700K 82 CRI L70 @ 250,000 Hours 500 Lumens	Integral DIM Line Voltage	4.5W	EA	UL Listed	CIRCA LIGHTING Logan Linear Tall Sconce #TV1222AI + Dimming Driver as required ARCHIPELAGO LIGHTING #LTB10F50027MB (QTY.: 2)	BY MEETING PERFORMANCE AND AESTHETIC SPECIFICATION & ADA COMPLIANCE.	1. Fixture shall dim. 2. Refer to architectural drawings for mounting height AFF, or at least 6'-8" AFF where the fixture protrudes 4" or more from the wall for ADA compliance - Architect to verify. Luminaire shall be mounted over a recessed junction box (by electrician). 3. Architect shall verify fixture finish. 4. Electrical Engineer/Contractor to verify compatibility of light source, gear and dimming system.
D7		Lounge	Surface mounted round LED downlight with steel frame body, opal glass diffuser, and dark bronze finish. Dimensions: Fixture: 18" dia. x 10" tall Warranty: 5 Years	LED 2700K 96 CRI N/A 2850 Lumens	Integral DIM MLV/ELV	48.0W	EA	UL Listed	HINKLEY Harper #3643OZ-LED	BY MEETING PERFORMANCE AND AESTHETIC SPECIFICATION	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Luminaire shall be mounted over a surface-mounted junction box (by electrician). 4. Electrical Engineer/Contractor to verify compatibility of light source, gear and dimming system.
EXTERIOR LUMINAIRES											
EX1		Egress Door	Wall mounted LED floodlight with machined aluminum housing, die-cast aluminum heat sink, solite glass lens, type 3 optic, and polyester powdercoat finish. Dimensions: Fixture: 3" Dia. x 8" tall Warranty: 5 Years	LED 3000K 80 CRI L70 @ 50,000 Hours 1000 Lumens	Integral DIM 0-10V	13.0W	EA	UL Listed	WILLIAMS LIGHTING "VWM" #VWM-H-L10-830-T3-FINISH-SDGL-DIM-UNV	SPECIFIED FIXTURE IS A CAMPUS STANDARD - NO SUBSTITUTIONS	1. Fixture shall dim. 2. Fixture shall be listed and labeled "suitable for wet locations". 3. Architect shall verify mounting height AFF with architectural elevations. 4. Luminaire shall be mounted over a recessed junction box (by electrician).
EX2		Vestibule	Recessed round LED downlight with with galvanized steel housing, self-flanged die cast aluminum bevel, 65º beam distribution, 1" regressed lens, integral solite lens, and painted finish. Dimensions: Fixture: 3" Width x 2" tall Warranty: 5 Years	LED 3000K 80+ CRI L70 @ 50,000 Hours 925 Lumens	Integral DIM (1% Dimming) 0-10V	9.0W	EA	UL Listed	USAI Beveled Mini Shallow Housing #B3RDF-09X3-30KS-65-S-TRIM FINISH-FLANGE FINISH-FT-UNV-D22	LUCIFER LIGHTING " FRAXION 4 SLIM"	1. Fixture shall dim. 2. Architect shall verify fixture finish. 3. Contractor shall verify and coordinate luminaire installation and mounting with architectural details, housing type, field conditions, and ceiling system details including ceiling thickness, grid type, flange and insulation clearance requirements. 4. Fixture shall be listed and labeled "suitable for wet locations". 5. Fixture shall meet shallow housing requirement of 2-1/2" height max. housing.
EX3		Exterior Pathway	Fixture: Post-top mounted LED pedestrian fixture with fully frosted polycarbonate lens, type V beam distribution, and powser coated finish. Dimensions: Fixture: 20" Width x 34" tall Pole: 13'-0" tall x 20" base Warranty: 5 Years	LED 3000K 80+ CRI N/A N/A	Integral N/A 0-10V	20.0W	EA	UL Listed	SPRING CITY Edgewater (Pole Top) + NorthHampton (Pole) #ALMED*-LE020-VOLTS-X5-30-CN5-A-PLF-FINIAL-FINISH (Fixture) + #APSNRT-20-13.00-TN-TENON-C-FINISH	SPECIFIED FIXTURE IS A CAMPUS STANDARD - NO SUBSTITUTION	1. Fixture shall dim. 2. Fixture shall be U.L. listed and labeled "suitable for wet locations". 3. Provide 13'-0" tall aluminum round pole sized to meet local AASHTO requirements for EPA. 4. Architect shall verify fixture and pole finishes. 5. Adequate drainage must be provided in concrete foundation for pole and pole base.

TYPE	APPLICATION IMAGE	LOCATION	DESCRIPTION	LAMPS/SOURCE	POWER SUPPLY/ DRIVER	INPUT WATTS	INPUT WATT UNITS	LISTING	MANUFACTURER	ALT	NOTES
EX4	  **WM5133** /11" x 16 3/8"	Exterior Arch	Arm mounted LED sconce with cast aluminum body, white opal acrylic lens, wide T5 beam spread, and powder coat finish. Dimensions: Fixture: 11" Width x 22-1/4" tall Warranty: 5 Years	LED 3000K 90+ CRI L70 @ 50,000 Hours 850 Lumens	Integral DIM (1% Dimming) 0-10V	11.0W	EA	UL Listed	ANP LIGHTING LA440 #LA440-3-WH-M009LD-D-W-30K-ACCESSORIES-WM5133-101	ELA "MEDITERRANEAN MED"	1. Fixture shall dim. 2. Fixture shall be U.L. listed and labeled "suitable for wet locations". 3. Refer to architectural drawings for mounting height AFF. Luminaire shall be mounted over a recessed junction box (by electrician). 4. Architect shall verify fixture finish. 5. Electrical Engineer/Contractor to verify compatibility of light source, gear and dimming system. 6. Specified fixture is to match existing campus fixture - Substitutions shall meet aesthetics of existing fixture including arm mounting.

APPENDIX – LIGHT FIXTURE CUTSHEETS

(This document is for information only. Refer to Appendix – Luminaire Schedule for all catalog numbers, lamps, finishes, etc.)

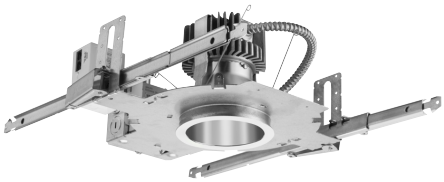
gotham® | E V O®

Multiple Layers of Light

Luminaire Type:

Catalog Number:

General Illumination Round Downlight 4"



OVERVIEW

Feature Set

- Bounding Ray™ optical design
- Unitized optics mechanically attach the light engine to the lower reflector for complete optical alignment.
- 45° cutoff to source and source image
- Fully serviceable and upgradeable lensed LED light engine
- 70% lumen maintenance at 60,000 hours
- 2.5 SDCM; 85 CRI typical, 90+ CRI optional
- Fixtures are wet location, covered ceiling
- Available with 10% dimming, 1% dimming, or dim to dark
- Batwing distribution with feathered edges provides even illumination on horizontal and vertical surfaces
- ENERGY STAR® certified product

Distribution

Superior Perfomance

Nominal Lumens	250	500	750	1000	1500	2000	2500	3000	3500
Delivered Lumens	271	573	808	1001	1527	1994	2580	3110	3612
Wattage	3.1	7.2	7.9	8.8	13.7	19.5	25.7	31.2	38.4
Lumens per Watt	87.4	79.6	102.3	113.8	111.5	102.3	100.4	99.7	94.1

COMPLIMENTARY PRODUCTS

Coordinated Apertures | Multiple Layers of Light

General Illumination Layer | EVO

High Center Beam Layer | Incito

EVO + Incito — Multiple Layers of Light

Core

Healthcare

Special Applications

GOTHAM ARCHITECTURAL DOWNLIGHTING | 1400 Lester Road Conyers, GA 30012 | P 800-705-SERV (7378) | gothamlighting.com

ORDERING INFORMATION

A+ Capable options indicated by this color background.

Design2Ship Quick Ship Program: Options in green text qualify for Design2Ship — 5 business days from order entry to ship. Refer to Design2Ship Brochure for complete program details. **Maximum Order Quantity: 100 units; 50 for Chicago Plenum.**

Luminaire Type:

Catalog Number:

EXAMPLE: EV04 35/25 AR MWD LSS 120 EZ1

Series	Color Temperature	Nominal Lumen Values	Reflector & Flange Color	Trim Style	Distribution	Finish	Voltage
EV04	27/ 2700 K 30/ 3000 K 35/ 3500 K 40/ 4000 K 50/ 5000 K	02 250 lumens 05 500 lumens 07 750 lumens 10 1000 lumens 15 1500 lumens 20 2000 lumens 25 2500 lumens 30 3000 lumens 35 3500 lumens	AR Clear PR Pewter WTR Wheat GR Gold WR[1] White BR[1] Black WRAMF[1] White Anti-microbial	(blank) Self-flanged FL Flangeless	MD Medium (0.9 s/mh) MWD Medium wide (1.0 s/mh) WD Wide (1.2 s/mh)	LSS Semi-specular LD Matte-diffuse LS Specular	MVOLT 120 277 347[2,3]

Driver[4]		Control Interface		Options	
GZ10	0-10V driver dims to 10%	NLT[6]	nLight® dimming pack controls	SF	Single Fuse. Specify 120V or 277V
GZ1	0-10V driver dims to 1%	NLTER[2,6,10]	nLight® dimming pack controls emergency circuit	TRW[7]	White painted flange
EZ10	eldoLED 0-10V ECOdrive. Linear dimming to 10% min.	NLTAIR2[13]	nLight® Air enabled	TRBL[8]	Black painted flange
EZ1	eldoLED 0-10V ECOdrive. Linear dimming to 1% min.	NLTAIRER2[2,10,13]	nLight® AIR Dimming Pack Wireless Controls. Controls fixtures on emergency circuit	EL[9]	Emergency battery pack, 10W, with integral test switch
EZB	eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%.	EXA1	XPoint Wireless, eldoLED 0-10V ECOdrive. Linear dimming to 1%. Refer to XPoint tech sheet.	ELR[9]	Emergency battery pack, 10W, with remote test switch
EDAB[4]	eldoLED SOLOdrive DALI. Logarithmic dimming to <1%.	EXAB	XPoint Wireless, eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%. Refer to XPoint tech sheet.	ELSD[9]	Emergency battery pack, 10W, with self-diagnostics, integral test switch
EDXB[4]	eldoLED POWERdrive DMX with RDM (remote device management). Square Law dimming to <1%. Minimum 1000 lumens. Includes termination resistor. Refer to DMXR Manual.			ELRSD[9]	Emergency battery pack, 10W, with self-diagnostics, remote test switch
ECOS2[5]	Lutron® Hi-Lume® 2-wire forward-phase driver.120V only. Minimum dimming level 1%. Minimum 1000 lumens.			E10WCP[9]	Emergency battery pack, 10W Constant Power, CA Title 20 compliant with integral test switch
ECOD[5]	Lutron Ecosystem digital Hi-Lume 1% soft-on, fade to black			E10WCPR[9]	Emergency battery pack, 10W Constant Power, CA Title 20 compliant with remote test switch
				N80[11]	nLight® Lumen Compensation
				BGTD	Bodine generator transfer device. Specify 120V or 277V.
				90CRI	High CRI (90+)
				CP[12]	Chicago Plenum. Specify 120V or 277V for 5000lm and above.
				RRL__	RELOC®-ready luminaire connectors enable a simple and consistent factory installed option across all ABL luminaire brands. Refer to RRL for complete nomenclature.

ACCESSORIES — order as separate catalog numbers (shipped separately)

SCA4	Sloped ceiling adapter. Degree of slope must be specified (5D, 10D, 15D, 20D, 25D, 30D). Ex: SCA4 10D. Refer to TECH-190.
CTA4-8 YK	Ceiling thickness adapter (extends mounting frame to accommodate ceiling thickness up to 5"). Adds ~4" to fixture height.
ISD BC	0-10V wallbox dimmer. Refer to ISD-BC.

ORDERING NOTES

1. Not available with finishes.
2. Not available with emergency battery pack options.
3. Supplied with factory installed step down transformer.
4. Refer to TECH-240 for compatible dimmers.
5. Not available with nLight® and XPoint options.
6. Must specify voltage.
7. For use with different reflector finish only (i.e. AR, PR, WTR, GR options). Not applicable with WR (white reflector) or FL (flangeless) option.
8. For use with different reflector finish only (i.e. AR, PR, WTR, GR options). Not applicable with BR (black reflector) or FL (flangeless) option.
9. 11" of plenum depth or top access required for battery pack maintenance.
10. ER for use with generator supply power. Will require an emergency hot feed and normal hot feed.
11. Fixture begins at 80% light level. Must be specified with NLT or NLTER. Only available with EZ10 and EZ1 drivers.
12. Not available with ELR, HAO, EXA1, or EXAB options.
13. Not available DALI or DMX drivers. Not available with CP or N80 options. Not recommended for metal ceiling installations.

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

SPECIFICATIONS

Optical Assemby

Fully serviceable and upgradeable lensed LED light engine suitable for field maintenance or service from below the ceiling.

Optical design is a Bounding Ray™ design with 45° cutoff to source and source image. Top-down flash characteristic for superior glare control.

Unitized optics shall have mechanical attachment of the light engine to the lower reflector for complete optical alignment.

Electrical

The luminaire shall operate from a 50 or 60 Hz ±3 Hz AC line over a voltage ranging from 120 VAC to 277 VAC. The fluctuations of line voltage shall have no visible effect on the luminous output.

The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.

Sound Rated A+. Driver shall be >80% efficient at full load across all input voltages.

Input wires shall be 18AWG, 300V minimum, solid copper.

Controls

Luminaire shall be equipped with interface for nLight wired or wireless network with integral power supply as per specification.

Dimming

The luminaire shall be capable of continuous dimming without perceivable stroboscopic flicker as measured by flicker index (ANSI/IES RP-16-10) over a range of 100 – 10%, 100 – 1.0% or 100 – 0.1% of rated lumen output with a smooth shut off function to step to 0%.

eldoLED LED drivers shall conform to IEEE P1789 standards. Alternatively, manufacturers must demonstrate conformance with product literature and testing which demonstrates this performance. Systems that do not meet IEEE P1789 will not be considered.

Driver is inaudible in 24dB environment, and stable when input voltage conditions fluctuate over what is typically experienced in a commercial environment.

Construction

Luminaire housing shall be constructed of 16-gauge galvanized steel and have preinstalled telescopic mounting bars with maximum 32" and minimum 15" extension and 4" vertical adjustment.

Luminaires shall be suitable for installation in ceilings up to 1½" thick. (specify ceiling thickness adapter to extend frame to accommodate ceiling thickness up to 2").

Tool-less adjustments shall be possible after installation.

The assembly and manufacturing process for the luminaire shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration.

25°C ambient temperature standard (1/2" clearance on all sides from non-combustible materials in non-IC applications, unless marked spacing noted otherwise). For use in insulated ceilings, a 3" clearance on all sides from insulation is required (unless marked spacing noted otherwise).

Listings

Fixtures are CSA certified to meet US and Canadian Standards: All fixtures manufactured in strict accordance with the appropriate and current requirements of the "Standards for Safety" to UL, wet location covered ceiling. Luminaire configurations are Energy Star certified through testing in EPA–recognized laboratories, with the results reviewed by an independent, accredited certification organization. Visit www.energystar.gov for specific configurations listed.

Photometrics

LEDs tested to LM-80 standards. Measured by IESNA Standard LM-79-08 in an accredited lab. Lumen output shall not decrease by more than 30% over the minimum operational life of 60,000 hours.

Color appearance from luminaire to luminaire of the same type and in all configurations, shall be consistent both initially and at 6,000 hours and operate within a tolerance of <2.5 MacAdam ellipse as defined by a point at the intersection of the CCT line and the black body locus line in CIE chromaticity space.

Warranty

5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/support/customer-support/terms-and-conditions

Note:

Actual performance may differ as a result of end user environment and application.

All values are design or typical values, measured under laboratory conditions at 25 °C.

A+ Capable Luminaire

This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

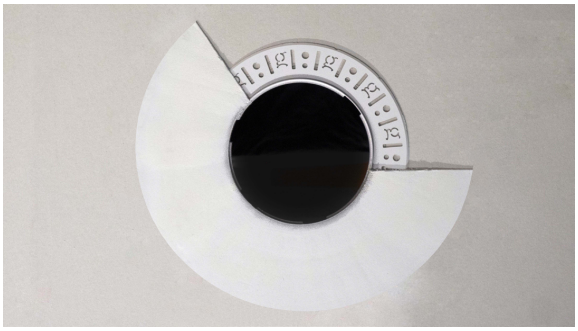
- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight® control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

Partially finished mud ring, showing cross-section detail.



An EVO downlight requires only approximately 3" of plaster to finish.

EVO with flangeless trim

Flangeless Installation

Gotham's flangeless option utilizes a micro-thin polymer mud ring that minimizes the amount of drywall compound required to finish the ceiling. The end result is a virtually undetectable flangeless downlight installation.

The polymer mud ring is installed independent of the of the recessed frame, therefore floating with the ceiling. This innovation minimizes any surface cracks during reflector installation, ceiling movement and any future service to the recessed frame, wiring, electronics, etc.

Tables of Use

EVO - eldoLED Driver Default Dimming Curve			
Nomenclature	Min Dimming	Driver Dim Curve	Control Dim Curve
EZ10	10%	Linear	Linear/Logarithmic
EZ1	1%	Linear	Linear/Logarithmic
EXA1	1%	Linear	Linear/Logarithmic
EZB	<1%	Logarithmic	Linear
EDAB	<1%	Logarithmic	Linear
EXAB	<1%	Logarithmic	Linear
EDXB	<1%	Logarithmic	Linear

CCT/CRI Multiplier Table		
CRI	CCT	Multiplier
80	2700K	0.96
	3000K	1.00
	3500K	1.00
	4000K	1.01
	5000K	1.07
90	2700K	0.80
	3000K	0.83
	3500K	0.85
	4000K	0.87
	5000K	0.91

Reflector Finish Multiplier	
Reflector Finish	Multiplier
LS - Specular	1
LSS - Semi Specular	0.956
WR - White	0.87
LD - Matte Diffuse	0.85
BR - Black	0.73

Driver		Control Provided (note: 347V/UVOLT versions provided with 347 option selected)			
Nomenclature	Description	NLT	NLTER	NLTAIR2	NLTAIR2ER
GZ10	0-10V driver dims to 10%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V ER G2
GZ1	0-10V driver dims to 1%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V ER G2
EZ10	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2
EZ1	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2
EZB	eldoLED 0-10V SOLOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2

How to Estimate Delivered Lumens in Emergency Mode

Delivered Lumens = 1.25 x P x LPW

P = Output power of emergency driver. P = 10W for PS1055CP

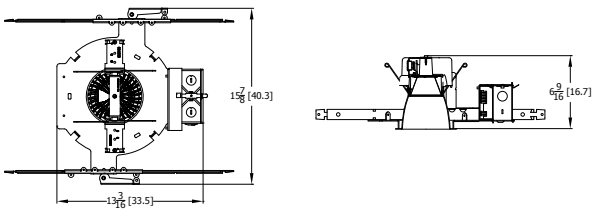
LPW = Lumen per watt rating of the luminaire. This information is available on the ABL luminaire spec sheet.

gotham®

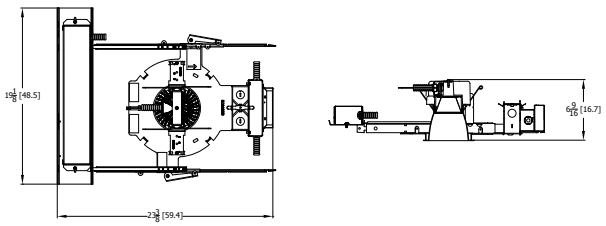
DIMENSIONAL DATA

Aperture: 4-5/16" (11)	Ceiling Opening: 5-1/8" (13) self-flanged
Overlap trim: 5-7/16" (13.8)	5-1/4" (13.3) flangeless

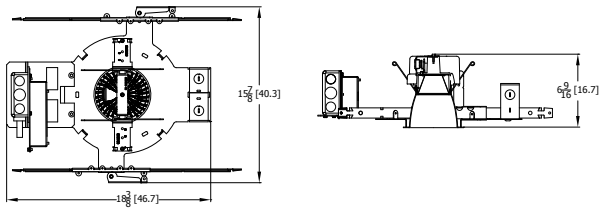
Standard



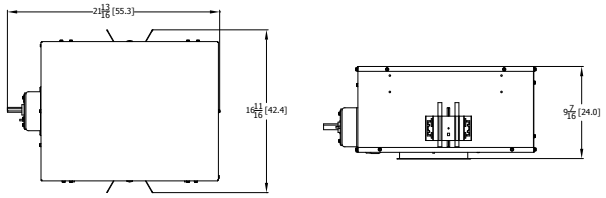
Battery Pack



CP Standard

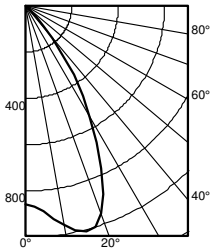


CP Enclosed For Use With Battery Pack & nLight



CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

EV04 35/10 MWD LS INPUT WATTS: 8.8W, DELIVERED LUMENS: 1001.7LM, LPW = 113.8, 1.08 S/MH, TEST NO. LTL27786P131



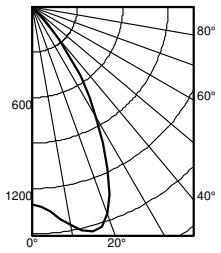
	Ave	Lumens
0	856	
5	888	87
15	1010	280
25	775	350
35	363	225
45	61	56
55	2	2
65	1	1
75	0	0
85	0	0
90	0	

Zone	Lumens	% Lamp
0° - 30°	717.4	71.6
0° - 40°	942.0	94.0
0° - 60°	1000.8	99.9
0° - 90°	1001.7	100.0
90° - 180°	0.0	0.0
0° - 180°	1001.7	*100.0
	*Efficiency	

pf	80%			70%			50%		
pc	20%			20%			20%		
pw	50%	30%	10%	50%	30%	10%	50%	30%	10%
0	119	119	119	116	116	116	111	111	111
1	111	108	106	109	106	104	105	103	101
2	103	99	96	101	98	95	98	95	93
3	96	91	87	95	90	87	92	88	85
4	90	84	80	89	84	80	87	82	79
5	84	78	74	83	78	74	81	77	73
6	79	73	69	78	72	68	76	72	68
7	74	68	64	73	68	64	72	67	63
8	70	64	59	69	63	59	68	63	59
9	66	60	56	65	59	56	64	59	55
10	62	56	52	61	56	52	61	56	52

		50% beam - 56.7°		10% beam - 79.7°	
Mounting Height	Inital FC Center Beam	Diameter	FC	Diameter	FC
8.0	28.3	5.9	14.1	9.2	2.8
10.0	15.2	8.1	7.6	12.5	1.5
12.0	9.5	10.3	4.7	15.9	0.9
14.0	6.5	12.4	3.2	19.2	0.6
16.0	4.7	14.6	2.3	22.5	0.5

EV04 35/15 MWD LSS INPUT WATTS: 13.7W, DELIVERED LUMENS: 1527.3LM, LPW = 111.4, 1.08 S/MH, TEST NO. LTL27786P137



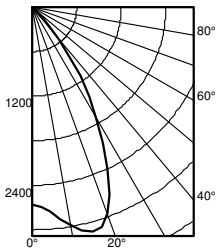
	Ave	Lumens
0	1305	
5	1354	133
15	1539	428
25	1181	533
35	553	342
45	93	86
55	2	4
65	1	1
75	0	0
85	0	0
90	0	

Zone	Lumens	% Lamp
0° - 30°	1093.9	71.6
0° - 40°	1436.2	94.0
0° - 60°	1525.8	99.9
0° - 90°	1527.3	100.0
90° - 180°	0.0	0.0
0° - 180°	1527.3	*100.0
	*Efficiency	

pf	80%			70%			50%		
pc	20%			20%			20%		
pw	50%	30%	10%	50%	30%	10%	50%	30%	10%
0	119	119	119	116	116	116	111	111	111
1	111	108	106	109	106	104	105	103	101
2	103	99	96	101	98	95	98	95	93
3	96	91	87	95	90	87	92	88	85
4	90	84	80	89	84	80	87	82	79
5	84	78	74	83	78	74	81	77	73
6	79	73	69	78	72	68	76	72	68
7	74	68	64	73	68	64	72	67	63
8	70	64	59	69	63	59	68	63	59
9	66	60	56	65	59	56	64	59	55
10	62	56	52	61	56	52	61	56	52

		50% beam - 56.7°		10% beam - 79.7°	
Mounting Height	Inital FC Center Beam	Diameter	FC	Diameter	FC
8.0	43.2	5.9	21.6	9.2	4.3
10.0	23.2	8.1	11.6	12.5	2.3
12.0	14.5	10.3	7.2	15.9	1.4
14.0	9.9	12.4	4.9	19.2	1.0
16.0	7.2	14.6	3.6	22.5	0.7

EV04 35/30 MWD LSS INPUT WATTS: 31.2W, DELIVERED LUMENS: 3110.6LM, LPW = 99.6, 1.08 S/MH, TEST NO. LTL27786P155



	Ave	Lumens
0	2659	
5	2758	271
15	3135	871
25	2406	1086
35	1126	697
45	189	175
55	5	7
65	2	2
75	0	1
85	0	0
90	0	

Zone	Lumens	% Lamp
0° - 30°	2227.9	71.6
0° - 40°	2925.0	94.0
0° - 60°	3107.6	99.9
0° - 90°	3110.6	100.0
90° - 180°	0.0	0.0
0° - 180°	3110.6	*100.0
	*Efficiency	

pf	80%			70%			50%		
pc	20%			20%			20%		
pw	50%	30%	10%	50%	30%	10%	50%	30%	10%
0	119	119	119	116	116	116	111	111	111
1	111	108	106	109	106	104	105	103	101
2	103	99	96	101	98	95	98	95	93
3	96	91	87	95	90	87	92	88	85
4	90	84	80	89	84	80	87	82	79
5	84	78	74	83	78	74	81	77	73
6	79	73	69	78	72	68	76	72	68
7	74	68	64	73	68	64	72	67	63
8	70	64	59	69	63	59	68	63	59
9	66	60	56	65	59	56	64	59	55
10	62	56	52	61	56	52	61	56	52

		50% beam - 56.7°		10% beam - 79.7°	
Mounting Height	Inital FC Center Beam	Diameter	FC	Diameter	FC
8.0	87.9	5.9	43.9	9.2	8.8
10.0	47.3	8.1	23.6	12.5	4.7
12.0	29.5	10.3	14.7	15.9	2.9
14.0	20.1	12.4	10.1	19.2	2.0
16.0	14.6	14.6	7.3	22.5	1.5

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NLIGHT AIR

nLight® AIR is the ideal solution for retrofit or new construction spaces where adding communication wiring is cost prohibitive. The integrated nLight AIR rPP20 Power Pack is part of each EVO Luminaire ordered with the NLTAIR option. These individually addressable controls offer the ultimate in flexibility during initial setup and for space repurposing.

nLight® AIR Control Accessories

Order as separate catalog number. Visit nLight AIR.

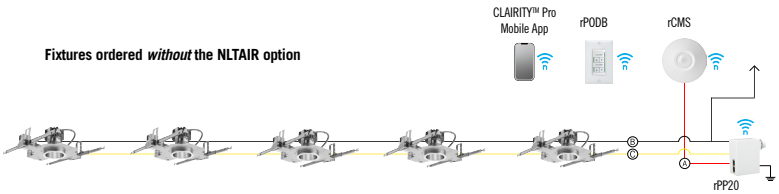
Wall Switches	Model Number
On/Off single pole	rPODB (color) G2
On/Off two pole	rPODB 2P (color) G2
On/Off & raise/lower single pole	rPODB DX (color) G2
On/Off & raise/lower two pole	rPODB 2P DX (color) G2

nLight® AIR Control Accessories *(cont.)*

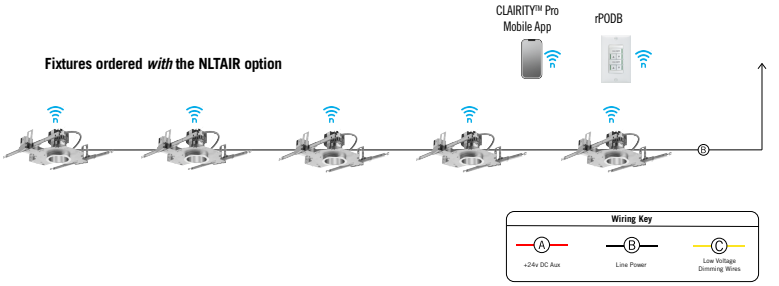
Occupancy Sensors (PIR/dual tech)	Model Number
Small motion 360°, ceiling	rCMS 9 / rCMS PDT 9
Large motion 360°, ceiling	rCMS 10 / rCMS PDT 10

Possibilites for nLight® AIR

Fixtures ordered *without* the NLTAIR option



Fixtures ordered *with* the NLTAIR option



NLIGHT

nLight® The nLight® solution is a digital networked lighting control system that provides both energy savings and increased user configurability by cost effectively integrating time-based, daylight-based, sensor-based and manual lighting control schemes.

nLight® Wired Control Accessories

Order as separate catalog number. Visit nLight.

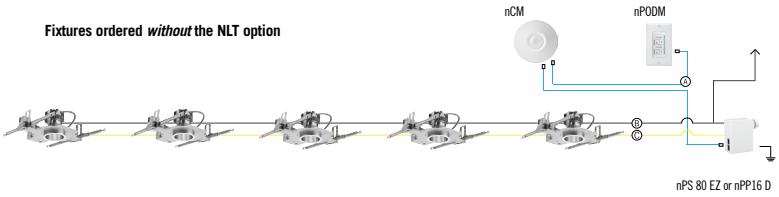
Wall Switches	Model Number
On/Off single pole	nPODM (color)
On/Off two pole	nPODM 2P (color)
On/Off & raise/lower single pole	nPOD DX (color)
On/Off & raise/lower two pole	nPODM 2P DX (color)
Graphic touchscreen	nPOD GFX (color)
Photocell Controls	
Dimming	nCM ADCX

nLight® Wired Control Accessories *(cont.)*

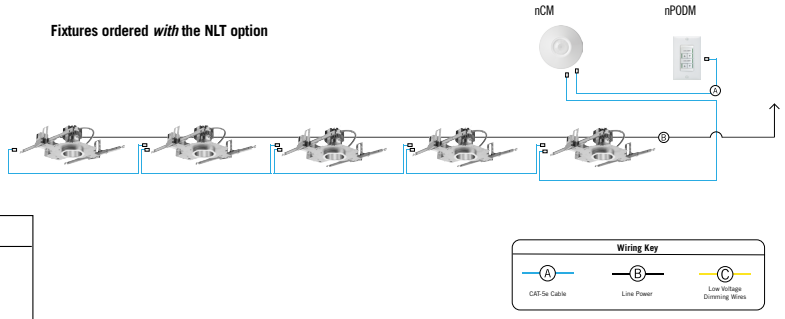
Occupancy Sensors (PIR/dual tech)	Model Number
Small motion 360°, ceiling	nCM 9 / nCM PDT 9
Large motion 360°, ceiling	nCM 10 / nCM PDT 10
Wide View	nWV 16 / nWV PDT 16
Wall switch with raise/lower	nWSX LV DX / nWSX PDT LV DX
Cat-5 Cables (plenum rated)	
10', CAT5	CAT5 10FT J1
15', CAT5	CAT5 15FT J1

Possibilites for nLight® wired

Fixtures ordered *without* the NLT option



Fixtures ordered *with* the NLT option



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NOT USED

gotham® | E V O®

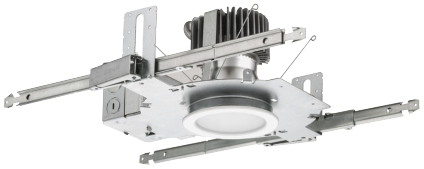
Multiple Layers of Light

Luminaire Type:

Catalog Number:

66 IP RATED

General Illumination Shower Downlight 4"



OVERVIEW

Feature Set

- Wipe down flush or regressed lens
- NSF2 Splash/Non-food Zone
- Fully serviceable and upgradeable lensed LED light engine
- 70% lumen maintenance at 60,000 hours
- 2.5 SDCM; 85 CRI typical, 90+ CRI optional
- IP66 rated room-side, Fixtures are wet location, covered ceiling
- Anti-microbial paint finish
- Non-conductive dead-front trim
- Suitable for steam room application

Distribution

medium wide
1.0 S:MH

Superior Perfomance

Nominal Lumens	250	500	750	1000	1500	2000	2500
Delivered	217	433	650	843	1281	1684	2165
Wattage	3.1	7.2	7.9	8.8	13.7	19.5	25.7
Efficacy	70.0	60.1	82.3	95.8	93.5	86.4	84.2

*Lumen output for 80CRI - 3500K

COMPLIMENTARY PRODUCTS

Coordinated Apertures | Multiple Layers of Light

General Illumination Layer | EVO

High Center Beam Layer | Incito

EVO + Incito — Multiple Layers of Light

Core

Healthcare

Special Applications

ORDERING INFORMATION

A+ Capable options indicated by this color background.

Luminaire Type:

Catalog Number:

EXAMPLE: EVO4SH 35/20 DFFAMF SOL MVOLT EZ10

Series	Color Temperature	Nominal Lumen Values	Lens Setting	Lens	Voltage
EVO4SH	27/ 2700 K 30/ 3000 K 35/ 3500 K 40/ 4000 K 50/ 5000 K	02 250 lumens 05 500 lumens 07 750 lumens 10 1000 lumens 15 1500 lumens 20 2000 lumens 25 2500 lumens	DFR Regressed lensed white painted trim DFF Flush lensed white painted trim DFRBR Regressed lensed black painted trim DFFBR Flush lensed black painted trim DFRAMF Regressed lensed trim with anti-microbial finish DFFAMF Flush lensed trim with anti-microbial finish	SOL Textured Lens SMO Smooth Clear Lens	MVOLT 120 277

Driver[1]	Controls Interface	Options
EZ10 eldoLED 0-10V ECOdrive. Linear dimming to 10% min. EZ1 eldoLED 0-10V ECOdrive. Linear dimming to 1% min. EZB eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%. EDAB eldoLED SOLOdrive DALI. Logarithmic dimming to <1%.	NLT[2] nLight® dimming pack controls 0-10V eldoLED drivers. NLTER[2,3] nLight® dimming pack controls 0-10V eldoLED drivers. ER controls fixtures on emergency circuit.	SF Single fuse. Specify 120V or 277V. ELR[4] Emergency battery pack, 10W, with remote test switch E10WCPR[4] Emergency battery pack, 10W Constant Power, CA Title 20 compliant with remote test switch BGTD Bodine generator transfer device. Specify 120V or 277V. 90CRI High CRI (90+). CP Chicago Plenum

ACCESSORIES — order as separate catalog numbers (shipped separately)

SCA4	Sloped ceiling adapter. Degree of slope must be specified (5D, 10D, 15D, 20D, 25D, 30D). Ex: SCA8 10D. Refer to TECH-190.
CTA4-8 YK	Ceiling thickness adapter (extends mounting frame to accommodate ceiling thickness up to 5"). Adds ~4" to fixture height.
ISD BC	0-10V wallbox dimmer. Refer to ISD-BC.

ORDERING NOTES

1. Refer to TECH-240 for compatible dimmers.
2. Specify Voltage.
3. For use with generator supply EM power. Will require an emergency hot feed and normal hot feed.
4. 11" of plenum depth or top access required for battery pack maintenance. Not available with CP option.

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

SPECIFICATIONS

Optical Assemby

Fully serviceable and upgradeable lensed LED light engine suitable for field maintenance or service from below the ceiling.

Unitized optics shall have mechanical attachment of the light engine to the lower reflector for complete optical alignment.

Electrical

The luminaire shall operate from a 50 or 60 Hz ±3 Hz AC line over a voltage ranging from 120 VAC to 277 VAC. The fluctuations of line voltage shall have no visible effect on the luminous output.

The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.

Sound Rated A+. Driver shall be >80% efficient at full load across all input voltages.

Input wires shall be 18AWG, 300V minimum, solid copper.

Controls

Luminaire shall be equipped with interface for nLight wired network with integral power supply as per specification.

Dimming

The luminaire shall be capable of continuous dimming without perceivable stroboscopic flicker as measured by flicker index (ANSI/IES RP-16-10) over a range of 100 – 10%, 100 – 1.0% or 100 – 0.1% of rated lumen output with a smooth shut off function to step to 0%.

eldoLED LED drivers shall conform to IEEE P1789 standards. Alternatively, manufacturers must demonstrate conformance with product literature and testing which demonstrates this performance. Systems that do not meet IEEE P1789 will not be considered.

Driver is inaudible in 24dB environment, and stable when input voltage conditions fluctuate over what is typically experienced in a commercial environment.

Construction

Luminaire housing shall be constructed of 16-gauge galvanized steel and have preinstalled telescopic mounting bars with maximum 32" and minimum 15" extension and 4" vertical adjustment.

Luminaires shall be suitable for installation in ceilings up to 1½" thick. (specify ceiling thickness adapter to extend frame to accommodate ceiling thickness up to 5").

Tool-less adjustments shall be possible after installation.

The assembly and manufacturing process for the luminaire shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration.

25°C ambient temperature standard (1/2" clearance on all sides from non-combustible materials in non-IC applications, unless marked spacing noted otherwise). For use in insulated ceilings, a 3" clearance on all sides from insulation is required (unless marked spacing noted otherwise).

Listings

Fixtures are CSA certified to meet US and Canadian standards: All fixtures manufactured in strict accordance with the appropriate and current requirements of the "Standards for Safety" to UL, wet location covered ceiling.

Photometrics

LEDs tested to LM-80 standards. Measured by IESNA Standard LM-79-08 in an accredited lab. Lumen output shall not decrease by more than 30% over the minimum operational life of 60,000 hours.

Color appearance from luminaire to luminaire of the same type and in all configurations, shall be consistent both initially and at 6,000 hours and operate within a tolerance of <2.5 MacAdam ellipse as defined by a point at the intersection of the CCT line and the black body locus line in CIE chromaticity space.

Warranty

5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/support/customer-support/terms-and-conditions

Note:

Actual performance may differ as a result of end user environment and application.

All values are design or typical values, measured under laboratory conditions at 25 °C.

A+ Capable Luminaire

This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight® control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

Tables of Use

DFF SMO - Flush Clear							
Nominal Lumens	250	500	750	1000	1500	2000	2500
Delivered	217	433	650	843	1281	1684	2165
Wattage	3.1	7.2	7.9	8.8	13.7	19.5	25.7
Efficacy	70.0	60.1	82.3	95.8	93.5	86.4	84.2

*Lumen output for 80CRI - 3500K

DFF SOL - Flush Textured							
Nominal Lumens	250	500	750	1000	1500	2000	2500
Delivered	206	412	618	801	1218	1602	2059
Wattage	3.1	7.2	7.9	8.8	13.7	19.5	25.7
Efficacy	66.5	57.2	78.2	91.0	88.9	82.2	80.1

*Lumen output for 80CRI - 3500K

DFR SMO - Regressed Clear							
Nominal Lumens	250	500	750	1000	1500	2000	2500
Delivered	170	339	509	660	1003	1319	1695
Wattage	3.1	7.2	7.9	8.8	13.7	19.5	25.7
Efficacy	54.8	47.1	64.4	75.0	73.2	67.6	66.0

*Lumen output for 80CRI - 3500K

DFR SOL - Regressed Textured							
Nominal Lumens	250	500	750	1000	1500	2000	2500
Delivered	157	314	471	611	929	1222	1571
Wattage	3.1	7.2	7.9	8.8	13.7	19.5	25.7
Efficacy	50.6	43.6	59.6	69.4	67.8	62.7	61.1

*Lumen output for 80CRI - 3500K

EVO - eldoLED Driver Default Dimming Curve			
Nomenclature	Min Dimming	Driver Dim Curve	Control Dim Curve
EZ10	10%	Linear	Linear/Logarithmic
EZ1	1%	Linear	Linear/Logarithmic
EXA1	1%	Linear	Linear/Logarithmic
EZB	<1%	Logarithmic	Linear
EDAB	<1%	Logarithmic	Linear
EXAB	<1%	Logarithmic	Linear
EDXB	<1%	Logarithmic	Linear

Lumen Output Multiplier		
CRI	CCT	Multplier
80	2700K	0.96
	300K	1.00
	3500K	1.00
	4000K	1.01
	5000K	1.07
90	2700K	0.80
	300K	0.83
	3500K	0.85
	4000K	0.87
	5000K	0.91

Reflector Finish Multiplier	
Reflector Finish	Multiplier
LS - Specular	1
LSS - Semi Specular	0.956
WR - White	0.87
LD - Matte Diffuse	0.85
BR - Black	0.73

Driver		Control Provided (note: 347V/UVOLT versions provided with 347 option selected)			
Nomenclature	Description	NLT	NLTER	NLTAIR2	NLTAIRER2
GZ10	0-10V driver dims to 10%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V ER G2
GZ1	0-10V driver dims to 1%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V ER G2
EZ10	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2
EZ1	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2
EZB	eldoLED 0-10V SOLOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2

How to Estimate Delivered Lumens in Emergency Mode

Delivered Lumens = 1.25 x P x LPW

P = Output power of emergency driver. P = 10W for PS1055CP

LPW = Lumen per watt rating of the luminaire. This information is available on the ABL luminaire spec sheet.

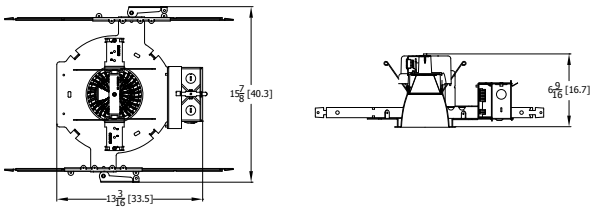
gotham

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

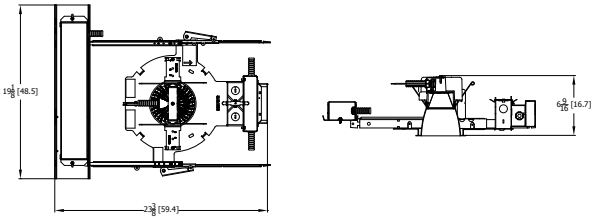
DIMENSIONAL DATA

Aperture: 4-5/16" (11)	Ceiling Opening: 5-1/8" (13) self-flanged
Overlap trim: 5-7/16" (13.8)	5-1/4" (13.3) flangeless

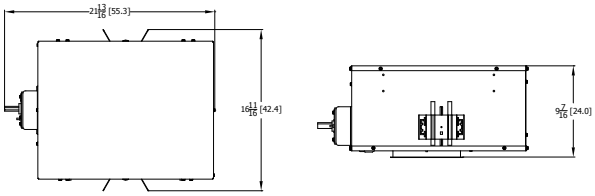
Standard



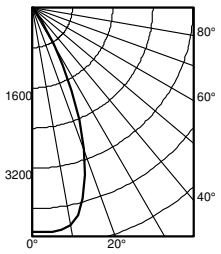
Battery Pack



CP Standard



EV04SH 35/25 4DFF SMO INPUT WATTS: 37.2W, DELIVERED LUMENS: 2650LM, LPW = 71.2, TEST NO. PT06171309



Ave	Lumens
0	4472
5	4485
15	3917
25	1832
35	297
45	86
55	23
65	13
75	7
85	3
90	0

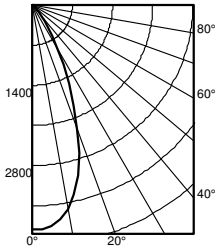
Zone	Lumens	% Lamp
0° - 30°	2318.5	87.5
0° - 40°	2541.2	95.9
0° - 60°	2626.8	99.1
0° - 90°	2649.8	100.0
90° - 180°	0.0	0.0
0° - 180°	2649.8	*100.0

*Efficiency

pf / pc	80%			70%			50%		
pw	50%	30%	10%	50%	30%	10%	50%	30%	10%
0	119	119	119	116	116	116	111	111	111
1	112	109	107	109	107	106	105	104	102
2	105	101	98	103	100	97	100	97	95
3	99	95	91	98	94	90	95	92	89
4	94	89	85	93	88	85	90	87	84
5	89	84	80	88	83	80	86	82	79
6	84	79	75	84	79	75	82	78	75
7	80	75	72	80	75	71	79	74	71
8	77	72	68	76	71	68	75	71	68
9	73	68	65	73	68	65	72	68	64
10	70	65	62	70	65	62	69	65	62

Mounting Height	Inital FC Center Beam	50% beam - 42.1° Diameter	50% beam - 42.1° FC	10% beam - 61.8° Diameter	10% beam - 61.8° FC
8.0	147.8	4.2	73.9	6.6	14.8
10.0	79.5	5.8	39.7	9.0	7.9
12.0	49.6	7.3	24.8	11.4	5.0
14.0	33.8	8.9	16.9	13.8	3.4
16.0	24.5	10.4	12.3	16.2	2.5

EV04SH 35/25 4DFF SOL INPUT WATTS: 37.2W, DELIVERED LUMENS: 2516LM, LPW = 67.6, TEST NO. PT06171308



Ave	Lumens
0	3917
5	3865
15	3076
25	1518
35	468
45	166
55	83
65	57
75	36
85	9
90	0

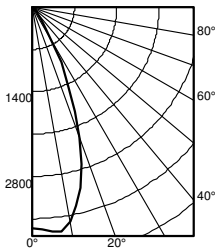
Zone	Lumens	% Lamp
0° - 30°	1892.4	75.2
0° - 40°	2202.3	87.5
0° - 60°	2412.1	95.9
0° - 90°	2516.2	100.0
90° - 180°	0.0	0.0
0° - 180°	2516.2	*100.0

*Efficiency

pf / pc	80%			70%			50%		
pw	50%	30%	10%	50%	30%	10%	50%	30%	10%
0	119	119	119	116	116	116	111	111	111
1	110	108	105	108	106	104	104	102	100
2	102	98	95	101	97	94	97	94	92
3	96	90	86	94	89	86	92	88	84
4	90	84	80	88	83	79	86	82	78
5	84	78	74	83	78	74	81	77	73
6	79	74	69	79	73	69	77	72	69
7	75	69	65	75	69	65	73	68	65
8	71	66	62	71	65	61	70	65	61
9	68	62	58	67	62	58	66	61	58
10	65	59	55	64	59	55	63	59	55

Mounting Height	Inital FC Center Beam	50% beam - 39.5° Diameter	50% beam - 39.5° FC	10% beam - 64.7° Diameter	10% beam - 64.7° FC
8.0	129.5	4.0	64.7	7.0	13.0
10.0	69.6	5.4	34.8	9.5	7.0
12.0	43.4	6.8	21.7	12.0	4.3
14.0	29.6	8.3	14.8	14.6	3.0
16.0	21.5	9.7	10.7	17.1	2.1

EV04SH 35/25 4DFR SMO INPUT WATTS: 37.2W, DELIVERED LUMENS: 2101LM, LPW =56.5, TEST NO. PT06171307



Ave	Lumens
0	3649
5	3734
15	3086
25	1425
35	245
45	70
55	16
65	9
75	4
85	0
90	0

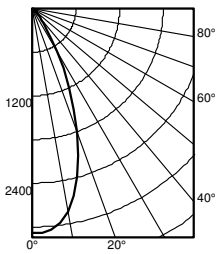
Zone	Lumens	% Lamp
0° - 30°	1837.9	87.5
0° - 40°	2020.3	96.2
0° - 60°	2086.5	99.3
0° - 90°	2100.9	100.0
90° - 180°	0.0	0.0
0° - 180°	2100.9	*100.0

*Efficiency

pf / pc	80%			70%			50%		
pw	50%	30%	10%	50%	30%	10%	50%	30%	10%
0	119	119	119	116	116	116	111	111	111
1	112	109	107	110	108	106	105	104	102
2	105	101	98	103	100	97	100	98	95
3	99	95	91	98	94	91	95	92	89
4	94	89	85	93	88	85	91	87	84
5	89	84	80	88	83	80	86	82	79
6	85	80	76	84	79	76	83	78	75
7	81	75	72	80	75	72	79	74	71
8	77	72	68	76	72	68	75	71	68
9	74	69	65	73	68	65	72	68	65
10	71	66	62	70	65	62	69	65	62

Mounting Height	Inital FC Center Beam	50% beam - 40.9° Diameter	50% beam - 40.9° FC	10% beam - 61.9° Diameter	10% beam - 61.9° FC
8.0	120.6	4.1	60.3	6.6	12.1
10.0	64.9	5.6	32.4	9.0	6.5
12.0	40.4	7.1	20.2	11.4	4.0
14.0	27.6	8.6	13.8	13.8	2.8
16.0	20.0	10.1	10.0	16.2	2.0

EV04SH 35/25 4DFR SOL INPUT WATTS: 37.2W, DELIVERED LUMENS: 1919LM, LPW = 51.6, TEST NO. PT06171306



Ave	Lumens
0	3089
5	3047
15	2395
25	1204
35	354
45	117
55	55
65	35
75	15
85	2
90	0

Zone	Lumens	% Lamp
0° - 30°	1485.5	77.4
0° - 40°	1721.3	89.7
0° - 60°	1866.4	97.2
0° - 90°	1919.2	100.0
90° - 180°	0.0	0.0
0° - 180°	1919.2	*100.0

*Efficiency

pf / pc	80%			70%			50%		
pw	50%	30%	10%	50%	30%	10%	50%	30%	10%
0	119	119	119	116	116	116	111	111	111
1	111	108	106	109	106	104	105	103	101
2	103	99	96	101	98	95	98	95	93
3	96	92	88	95	91	87	92	89	86
4	91	85	81	89	84	81	87	83	80
5	85	80	76	84	79	75	83	78	75
6	81	75	71	80	74	71	78	74	70
7	76	71	67	76	70	66	74	70	66
8	72	67	63	72	67	63	71	66	63
9	69	63	60	69	63	60	68	63	59
10	66	60	57	65	60	57	65	60	56

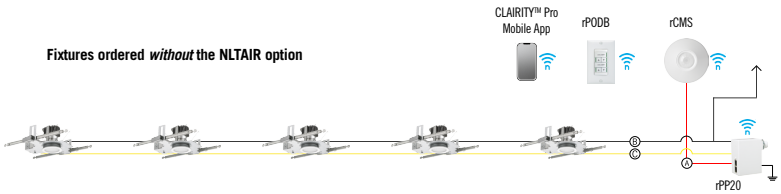
Mounting Height	Inital FC Center Beam	50% beam - 39.3° Diameter	50% beam - 39.3° FC	10% beam - 64.5° Diameter	10% beam - 64.5° FC
8.0	102.1	3.9	51.0	6.9	10.2
10.0	54.9	5.4	27.5	9.5	5.5
12.0	34.2	6.8	17.1	12.0	3.4
14.0	23.4	8.2	11.7	14.5	2.3
16.0	16.9	9.7	8.5	17.0	1.7

NLIGHT AIR

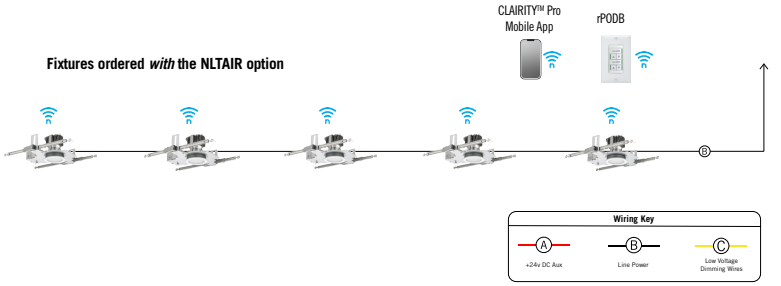
nLight® AIR is the ideal solution for retrofit or new construction spaces where adding communication wiring is cost prohibitive. The integrated nLight AIR rPP20 Power Pack is part of each EVO Luminaire ordered with the NLTAIR option. These individually addressable controls offer the ultimate in flexibility during initial setup and for space repurposing.

Possibilites for nLight® AIR

Fixtures ordered *without* the NLTAIR option



Fixtures ordered *with* the NLTAIR option



nLight® AIR Control Accessories
Order as separate catalog number. Visit nLight AIR.

Wall Switches	Model Number
On/Off single pole	rPODB (color) G2
On/Off two pole	rPODB 2P (color) G2
On/Off & raise/lower single pole	rPODB DX (color) G2
On/Off & raise/lower two pole	rPODB 2P DX (color) G2

nLight® AIR Control Accessories *(cont.)*

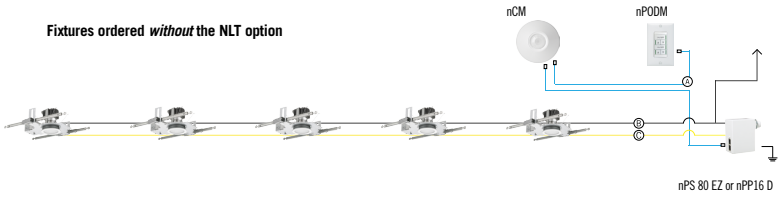
Occupancy Sensors (PIR/dual tech)	Model Number
Small motion 360°, ceiling	rCMS 9 / rCMS PDT 9
Large motion 360°, ceiling	rCMS 10 / rCMS PDT 10

NLIGHT

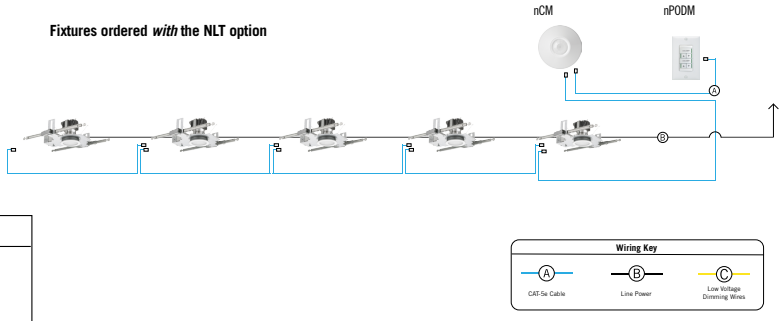
nLight® The nLight® solution is a digital networked lighting control system that provides both energy savings and increased user configurability by cost effectively integrating time-based, daylight-based, sensor-based and manual lighting control schemes.

Possibilites for nLight® wired

Fixtures ordered *without* the NLT option



Fixtures ordered *with* the NLT option



nLight® Wired Control Accessories
Order as separate catalog number. Visit nLight.

Wall Switches	Model Number
On/Off single pole	nPODM (color)
On/Off two pole	nPODM 2P (color)
On/Off & raise/lower single pole	nPOD DX (color)
On/Off & raise/lower two pole	nPODM 2P DX (color)
Graphic touchscreen	nPOD GFX (color)
Photocell Controls	
Dimming	nCM ADCX

nLight® Wired Control Accessories *(cont.)*

Occupancy Sensors (PIR/dual tech)	Model Number
Small motion 360°, ceiling	nCM 9 / nCM PDT 9
Large motion 360°, ceiling	nCM 10 / nCM PDT 10
Wide View	nWV 16 / nWV PDT 16
Wall switch with raise/lower	nWSX LV DX / nWSX PDT LV DX
Cat-5 Cables (plenum rated)	
10', CAT5	CAT5 10FT J1
15', CAT5	CAT5 15FT J1

gotham®

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

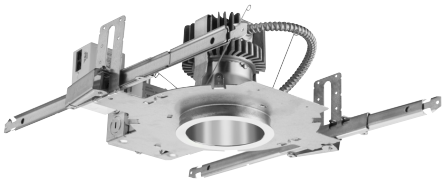
gotham® | E V O®

Multiple Layers of Light

Luminaire Type:

Catalog Number:

General Illumination Round Downlight 4"



OVERVIEW

Feature Set

- Bounding Ray™ optical design
- Unitized optics mechanically attach the light engine to the lower reflector for complete optical alignment.
- 45° cutoff to source and source image
- Fully serviceable and upgradeable lensed LED light engine
- 70% lumen maintenance at 60,000 hours
- 2.5 SDCM; 85 CRI typical, 90+ CRI optional
- Fixtures are wet location, covered ceiling
- Available with 10% dimming, 1% dimming, or dim to dark
- Batwing distribution with feathered edges provides even illumination on horizontal and vertical surfaces
- ENERGY STAR® certified product

Distribution

Superior Perfomance

Nominal Lumens	250	500	750	1000	1500	2000	2500	3000	3500
Delivered Lumens	271	573	808	1001	1527	1994	2580	3110	3612
Wattage	3.1	7.2	7.9	8.8	13.7	19.5	25.7	31.2	38.4
Lumens per Watt	87.4	79.6	102.3	113.8	111.5	102.3	100.4	99.7	94.1

COMPLIMENTARY PRODUCTS

Coordinated Apertures | Multiple Layers of Light

General Illumination Layer | EVO

High Center Beam Layer | Incito

EVO + Incito — Multiple Layers of Light

Core

Healthcare

Special Applications

GOTHAM ARCHITECTURAL DOWNLIGHTING | 1400 Lester Road Conyers, GA 30012 | P 800-705-SERV (7378) | gothamlighting.com

ORDERING INFORMATION

A+ Capable options indicated by this color background.

Design2Ship Quick Ship Program: Options in green text qualify for Design2Ship — 5 business days from order entry to ship. Refer to Design2Ship Brochure for complete program details. **Maximum Order Quantity: 100 units; 50 for Chicago Plenum.**

Luminaire Type:

Catalog Number:

EXAMPLE: EV04 35/25 AR MWD LSS 120 EZ1

Series	Color Temperature	Nominal Lumen Values	Reflector & Flange Color	Trim Style	Distribution	Finish	Voltage
EV04	27/ 2700 K 30/ 3000 K 35/ 3500 K 40/ 4000 K 50/ 5000 K	02 250 lumens 05 500 lumens 07 750 lumens 10 1000 lumens 15 1500 lumens 20 2000 lumens 25 2500 lumens 30 3000 lumens 35 3500 lumens	AR Clear PR Pewter WTR Wheat GR Gold WR[1] White BR[1] Black WRAMF[1] White Anti-microbial	(blank) Self-flanged FL Flangeless	MD Medium (0.9 s/mh) MWD Medium wide (1.0 s/mh) WD Wide (1.2 s/mh)	LSS Semi-specular LD Matte-diffuse LS Specular	MVOLT 120 277 347[2,3]

Driver[4]		Control Interface		Options	
GZ10	0-10V driver dims to 10%	NLT[6]	nLight® dimming pack controls	SF	Single Fuse. Specify 120V or 277V
GZ1	0-10V driver dims to 1%	NLTER[2,6,10]	nLight® dimming pack controls emergency circuit	TRW[7]	White painted flange
EZ10	eldoLED 0-10V ECOdrive. Linear dimming to 10% min.	NLTAIR2[13]	nLight® Air enabled	TRBL[8]	Black painted flange
EZ1	eldoLED 0-10V ECOdrive. Linear dimming to 1% min.	NLTAIRER2[2,10,13]	nLight® AIR Dimming Pack Wireless Controls. Controls fixtures on emergency circuit	EL[9]	Emergency battery pack, 10W, with integral test switch
EZB	eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%.	EXA1	XPoint Wireless, eldoLED 0-10V ECOdrive. Linear dimming to 1%. Refer to XPoint tech sheet.	ELR[9]	Emergency battery pack, 10W, with remote test switch
EDAB[4]	eldoLED SOLOdrive DALI. Logarithmic dimming to <1%.	EXAB	XPoint Wireless, eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%. Refer to XPoint tech sheet.	ELSD[9]	Emergency battery pack, 10W, with self-diagnostics, integral test switch
EDXB[4]	eldoLED POWERdrive DMX with RDM (remote device management). Square Law dimming to <1%. Minimum 1000 lumens. Includes termination resistor. Refer to DMXR Manual.			ELRSD[9]	Emergency battery pack, 10W, with self-diagnostics, remote test switch
ECOS2[5]	Lutron® Hi-Lume® 2-wire forward-phase driver.120V only. Minimum dimming level 1%. Minimum 1000 lumens.			E10WCP[9]	Emergency battery pack, 10W Constant Power, CA Title 20 compliant with integral test switch
ECOD[5]	Lutron Ecosystem digital Hi-Lume 1% soft-on, fade to black			E10WCPR[9]	Emergency battery pack, 10W Constant Power, CA Title 20 compliant with remote test switch
				N80[11]	nLight® Lumen Compensation
				BGTD	Bodine generator transfer device. Specify 120V or 277V.
				90CRI	High CRI (90+)
				CP[12]	Chicago Plenum. Specify 120V or 277V for 5000lm and above.
				RRL__	RELOC®-ready luminaire connectors enable a simple and consistent factory installed option across all ABL luminaire brands. Refer to RRL for complete nomenclature.

ACCESSORIES — order as separate catalog numbers (shipped separately)

SCA4	Sloped ceiling adapter. Degree of slope must be specified (5D, 10D, 15D, 20D, 25D, 30D). Ex: SCA4 10D. Refer to TECH-190.
CTA4-8 YK	Ceiling thickness adapter (extends mounting frame to accommodate ceiling thickness up to 5"). Adds ~4" to fixture height.
ISD BC	0-10V wallbox dimmer. Refer to ISD-BC.

ORDERING NOTES

1. Not available with finishes.
2. Not available with emergency battery pack options.
3. Supplied with factory installed step down transformer.
4. Refer to TECH-240 for compatible dimmers.
5. Not available with nLight® and XPoint options.
6. Must specify voltage.
7. For use with different reflector finish only (i.e. AR, PR, WTR, GR options). Not applicable with WR (white reflector) or FL (flangeless) option.
8. For use with different reflector finish only (i.e. AR, PR, WTR, GR options). Not applicable with BR (black reflector) or FL (flangeless) option.
9. 11" of plenum depth or top access required for battery pack maintenance.
10. ER for use with generator supply power. Will require an emergency hot feed and normal hot feed.
11. Fixture begins at 80% light level. Must be specified with NLT or NLTER. Only available with EZ10 and EZ1 drivers.
12. Not available with ELR, HAO, EXA1, or EXAB options.
13. Not available DALI or DMX drivers. Not available with CP or N80 options. Not recommended for metal ceiling installations.

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

SPECIFICATIONS

Optical Assemby

Fully serviceable and upgradeable lensed LED light engine suitable for field maintenance or service from below the ceiling.

Optical design is a Bounding Ray™ design with 45° cutoff to source and source image. Top-down flash characteristic for superior glare control.

Unitized optics shall have mechanical attachment of the light engine to the lower reflector for complete optical alignment.

Electrical

The luminaire shall operate from a 50 or 60 Hz ±3 Hz AC line over a voltage ranging from 120 VAC to 277 VAC. The fluctuations of line voltage shall have no visible effect on the luminous output.

The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.

Sound Rated A+. Driver shall be >80% efficient at full load across all input voltages.

Input wires shall be 18AWG, 300V minimum, solid copper.

Controls

Luminaire shall be equipped with interface for nLight wired or wireless network with integral power supply as per specification.

Dimming

The luminaire shall be capable of continuous dimming without perceivable stroboscopic flicker as measured by flicker index (ANSI/IES RP-16-10) over a range of 100 – 10%, 100 – 1.0% or 100 – 0.1% of rated lumen output with a smooth shut off function to step to 0%.

eldoLED LED drivers shall conform to IEEE P1789 standards. Alternatively, manufacturers must demonstrate conformance with product literature and testing which demonstrates this performance. Systems that do not meet IEEE P1789 will not be considered.

Driver is inaudible in 24dB environment, and stable when input voltage conditions fluctuate over what is typically experienced in a commercial environment.

Construction

Luminaire housing shall be constructed of 16-gauge galvanized steel and have preinstalled telescopic mounting bars with maximum 32" and minimum 15" extension and 4" vertical adjustment.

Luminaires shall be suitable for installation in ceilings up to 1½" thick. (specify ceiling thickness adapter to extend frame to accommodate ceiling thickness up to 2").

Tool-less adjustments shall be possible after installation.

The assembly and manufacturing process for the luminaire shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration.

25°C ambient temperature standard (1/2" clearance on all sides from non-combustible materials in non-IC applications, unless marked spacing noted otherwise). For use in insulated ceilings, a 3" clearance on all sides from insulation is required (unless marked spacing noted otherwise).

Listings

Fixtures are CSA certified to meet US and Canadian Standards: All fixtures manufactured in strict accordance with the appropriate and current requirements of the "Standards for Safety" to UL, wet location covered ceiling. Luminaire configurations are Energy Star certified through testing in EPA–recognized laboratories, with the results reviewed by an independent, accredited certification organization. Visit www.energystar.gov for specific configurations listed.

Photometrics

LEDs tested to LM-80 standards. Measured by IESNA Standard LM-79-08 in an accredited lab. Lumen output shall not decrease by more than 30% over the minimum operational life of 60,000 hours.

Color appearance from luminaire to luminaire of the same type and in all configurations, shall be consistent both initially and at 6,000 hours and operate within a tolerance of <2.5 MacAdam ellipse as defined by a point at the intersection of the CCT line and the black body locus line in CIE chromaticity space.

Warranty

5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/support/customer-support/terms-and-conditions

Note:

Actual performance may differ as a result of end user environment and application.

All values are design or typical values, measured under laboratory conditions at 25 °C.

A+ Capable Luminaire

This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

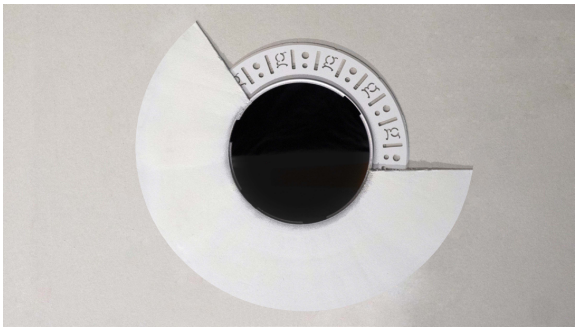
- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight® control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

Partially finished mud ring, showing cross-section detail.



An EVO downlight requires only approximately 3" of plaster to finish.

EVO with flangeless trim

Flangeless Installation

Gotham's flangeless option utilizes a micro-thin polymer mud ring that minimizes the amount of drywall compound required to finish the ceiling. The end result is a virtually undetectable flangeless downlight installation.

The polymer mud ring is installed independent of the of the recessed frame, therefore floating with the ceiling. This innovation minimizes any surface cracks during reflector installation, ceiling movement and any future service to the recessed frame, wiring, electronics, etc.

Tables of Use

EVO - eldoLED Driver Default Dimming Curve			
Nomenclature	Min Dimming	Driver Dim Curve	Control Dim Curve
EZ10	10%	Linear	Linear/Logarithmic
EZ1	1%	Linear	Linear/Logarithmic
EXA1	1%	Linear	Linear/Logarithmic
EZB	<1%	Logarithmic	Linear
EDAB	<1%	Logarithmic	Linear
EXAB	<1%	Logarithmic	Linear
EDXB	<1%	Logarithmic	Linear

CCT/CRI Multiplier Table		
CRI	CCT	Multiplier
80	2700K	0.96
	3000K	1.00
	3500K	1.00
	4000K	1.01
	5000K	1.07
90	2700K	0.80
	3000K	0.83
	3500K	0.85
	4000K	0.87
	5000K	0.91

Reflector Finish Multiplier	
Reflector Finish	Multiplier
LS - Specular	1
LSS - Semi Specular	0.956
WR - White	0.87
LD - Matte Diffuse	0.85
BR - Black	0.73

Driver		Control Provided (note: 347V/UVOLT versions provided with 347 option selected)			
Nomenclature	Description	NLT	NLTER	NLTAIR2	NLTAIR2ER
GZ10	0-10V driver dims to 10%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V ER G2
GZ1	0-10V driver dims to 1%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V ER G2
EZ10	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2
EZ1	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2
EZB	eldoLED 0-10V SOLOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2

How to Estimate Delivered Lumens in Emergency Mode

Delivered Lumens = 1.25 x P x LPW

P = Output power of emergency driver. P = 10W for PS1055CP

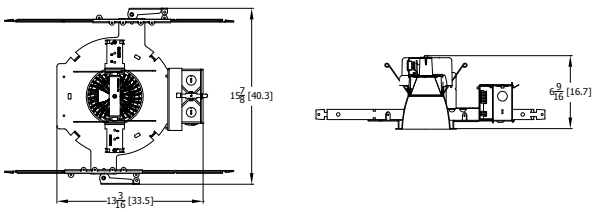
LPW = Lumen per watt rating of the luminaire. This information is available on the ABL luminaire spec sheet.

DIMENSIONAL DATA

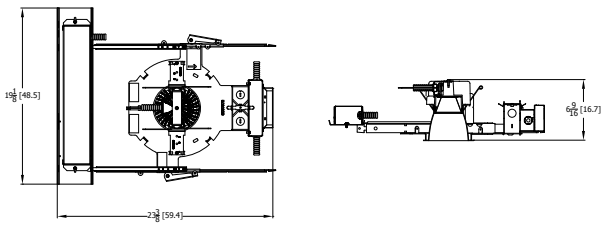
Aperture: 4-5/16" (11) Ceiling Opening: 5-1/8" (13) self-flanged

Overlap trim: 5-7/16" (13.8) 5-1/4" (13.3) flangeless

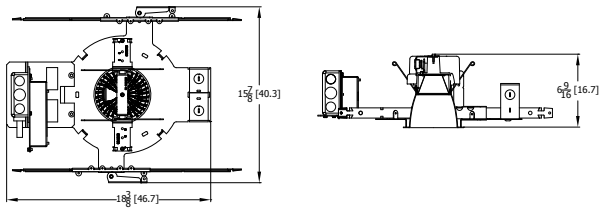
Standard



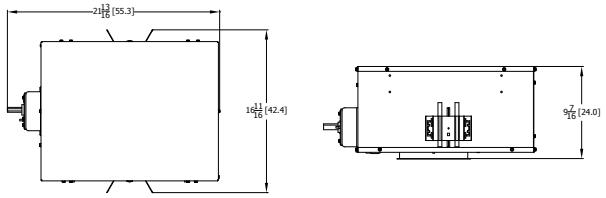
Battery Pack



CP Standard

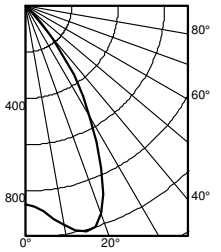


CP Enclosed For Use With Battery Pack & nLight



CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

EV04 35/10 MWD LS INPUT WATTS: 8.8W, DELIVERED LUMENS: 1001.7LM, LPW = 113.8, 1.08 S/MH, TEST NO. LTL27786P131



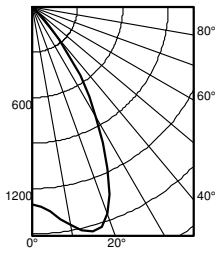
	Ave	Lumens
0	856	
5	888	87
15	1010	280
25	775	350
35	363	225
45	61	56
55	2	2
65	1	1
75	0	0
85	0	0
90	0	

Zone	Lumens	% Lamp
0° - 30°	717.4	71.6
0° - 40°	942.0	94.0
0° - 60°	1000.8	99.9
0° - 90°	1001.7	100.0
90° - 180°	0.0	0.0
0° - 180°	1001.7	*100.0
	*Efficiency	

pf	20%								
pc	80%			70%			50%		
pw	50%	30%	10%	50%	30%	10%	50%	30%	10%
0	119	119	119	116	116	116	111	111	111
1	111	108	106	109	106	104	105	103	101
2	103	99	96	101	98	95	98	95	93
3	96	91	87	95	90	87	92	88	85
4	90	84	80	89	84	80	87	82	79
5	84	78	74	83	78	74	81	77	73
6	79	73	69	78	72	68	76	72	68
7	74	68	64	73	68	64	72	67	63
8	70	64	59	69	63	59	68	63	59
9	66	60	56	65	59	56	64	59	55
10	62	56	52	61	56	52	61	56	52

		50% beam - 56.7°		10% beam - 79.7°	
Mounting Height	Inital FC Center Beam	Diameter	FC	Diameter	FC
8.0	28.3	5.9	14.1	9.2	2.8
10.0	15.2	8.1	7.6	12.5	1.5
12.0	9.5	10.3	4.7	15.9	0.9
14.0	6.5	12.4	3.2	19.2	0.6
16.0	4.7	14.6	2.3	22.5	0.5

EV04 35/15 MWD LSS INPUT WATTS: 13.7W, DELIVERED LUMENS: 1527.3LM, LPW = 111.4, 1.08 S/MH, TEST NO. LTL27786P137



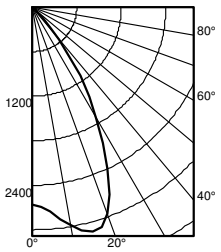
	Ave	Lumens
0	1305	
5	1354	133
15	1539	428
25	1181	533
35	553	342
45	93	86
55	2	4
65	1	1
75	0	0
85	0	0
90	0	

Zone	Lumens	% Lamp
0° - 30°	1093.9	71.6
0° - 40°	1436.2	94.0
0° - 60°	1525.8	99.9
0° - 90°	1527.3	100.0
90° - 180°	0.0	0.0
0° - 180°	1527.3	*100.0
	*Efficiency	

pf	20%								
pc	80%			70%			50%		
pw	50%	30%	10%	50%	30%	10%	50%	30%	10%
0	119	119	119	116	116	116	111	111	111
1	111	108	106	109	106	104	105	103	101
2	103	99	96	101	98	95	98	95	93
3	96	91	87	95	90	87	92	88	85
4	90	84	80	89	84	80	87	82	79
5	84	78	74	83	78	74	81	77	73
6	79	73	69	78	72	68	76	72	68
7	74	68	64	73	68	64	72	67	63
8	70	64	59	69	63	59	68	63	59
9	66	60	56	65	59	56	64	59	55
10	62	56	52	61	56	52	61	56	52

		50% beam - 56.7°		10% beam - 79.7°	
Mounting Height	Inital FC Center Beam	Diameter	FC	Diameter	FC
8.0	43.2	5.9	21.6	9.2	4.3
10.0	23.2	8.1	11.6	12.5	2.3
12.0	14.5	10.3	7.2	15.9	1.4
14.0	9.9	12.4	4.9	19.2	1.0
16.0	7.2	14.6	3.6	22.5	0.7

EV04 35/30 MWD LSS INPUT WATTS: 31.2W, DELIVERED LUMENS: 3110.6LM, LPW = 99.6, 1.08 S/MH, TEST NO. LTL27786P155



	Ave	Lumens
0	2659	
5	2758	271
15	3135	871
25	2406	1086
35	1126	697
45	189	175
55	5	7
65	2	2
75	0	1
85	0	0
90	0	

Zone	Lumens	% Lamp
0° - 30°	2227.9	71.6
0° - 40°	2925.0	94.0
0° - 60°	3107.6	99.9
0° - 90°	3110.6	100.0
90° - 180°	0.0	0.0
0° - 180°	3110.6	*100.0
	*Efficiency	

pf	20%								
pc	80%			70%			50%		
pw	50%	30%	10%	50%	30%	10%	50%	30%	10%
0	119	119	119	116	116	116	111	111	111
1	111	108	106	109	106	104	105	103	101
2	103	99	96	101	98	95	98	95	93
3	96	91	87	95	90	87	92	88	85
4	90	84	80	89	84	80	87	82	79
5	84	78	74	83	78	74	81	77	73
6	79	73	69	78	72	68	76	72	68
7	74	68	64	73	68	64	72	67	63
8	70	64	59	69	63	59	68	63	59
9	66	60	56	65	59	56	64	59	55
10	62	56	52	61	56	52	61	56	52

		50% beam - 56.7°		10% beam - 79.7°	
Mounting Height	Inital FC Center Beam	Diameter	FC	Diameter	FC
8.0	87.9	5.9	43.9	9.2	8.8
10.0	47.3	8.1	23.6	12.5	4.7
12.0	29.5	10.3	14.7	15.9	2.9
14.0	20.1	12.4	10.1	19.2	2.0
16.0	14.6	14.6	7.3	22.5	1.5

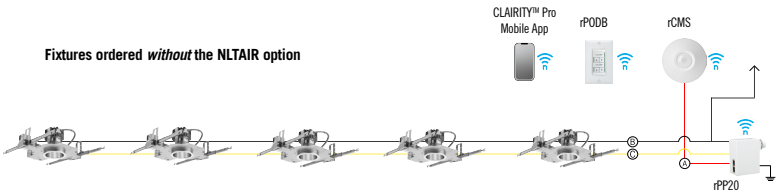
gotham®

NLIGHT AIR

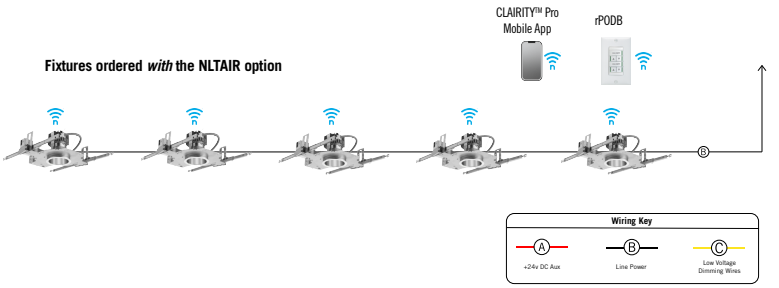
nLight® AIR is the ideal solution for retrofit or new construction spaces where adding communication wiring is cost prohibitive. The integrated nLight AIR rPP20 Power Pack is part of each EVO Luminaire ordered with the NLTAIR option. These individually addressable controls offer the ultimate in flexibility during initial setup and for space repurposing.

Possibilites for nLight® AIR

Fixtures ordered *without* the NLTAIR option



Fixtures ordered *with* the NLTAIR option



nLight® AIR Control Accessories *Order as separate catalog number. Visit nLight AIR.*	
Wall Switches	**Model Number**
On/Off single pole	rPODB (color) G2
On/Off two pole	rPODB 2P (color) G2
On/Off & raise/lower single pole	rPODB DX (color) G2
On/Off & raise/lower two pole	rPODB 2P DX (color) G2

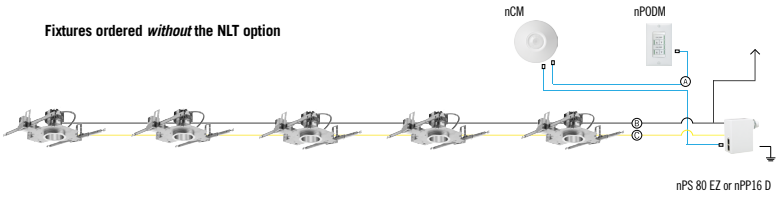
nLight® AIR Control Accessories *(cont.)*	
Occupancy Sensors (PIR/dual tech)	**Model Number**
Small motion 360°, ceiling	rCMS 9 / rCMS PDT 9
Large motion 360°, ceiling	rCMS 10 / rCMS PDT 10

NLIGHT

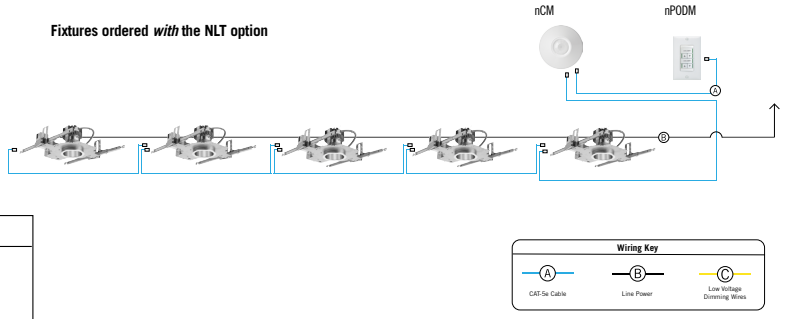
nLight® The nLight® solution is a digital networked lighting control system that provides both energy savings and increased user configurability by cost effectively integrating time-based, daylight-based, sensor-based and manual lighting control schemes.

Possibilites for nLight® wired

Fixtures ordered *without* the NLT option



Fixtures ordered *with* the NLT option



nLight® Wired Control Accessories *Order as separate catalog number. Visit nLight.*	
Wall Switches	**Model Number**
On/Off single pole	nPODM (color)
On/Off two pole	nPODM 2P (color)
On/Off & raise/lower single pole	nPOD DX (color)
On/Off & raise/lower two pole	nPODM 2P DX (color)
Graphic touchscreen	nPOD GFX (color)
Photocell Controls	
Dimming	nCM ADCX

nLight® Wired Control Accessories *(cont.)*	
Occupancy Sensors (PIR/dual tech)	**Model Number**
Small motion 360°, ceiling	nCM 9 / nCM PDT 9
Large motion 360°, ceiling	nCM 10 / nCM PDT 10
Wide View	nWV 16 / nWV PDT 16
Wall switch with raise/lower	nWSX LV DX / nWSX PDT LV DX
Cat-5 Cables (plenum rated)	
10', CAT5	CAT5 10FT J1
15', CAT5	CAT5 15FT J1

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

NOT USED

Novato Drum - Ceiling

AIC11866 36 in

SPI LIGHTING
PROJECT DETAILS

JOB NAME:
TYPE:
NOTES:

DESCRIPTION

While highly functional, the Novato family provides a playful twist to make a lasting impression. Versatility is the main strength of this collection as they are perfectly suited for a wide range of modern or traditional environments. Customize your visual environment with the Novato Drum by choosing a matte acrylic diffuser or from four fabric options. Available in 16", 24", 36", and 48" diameters.

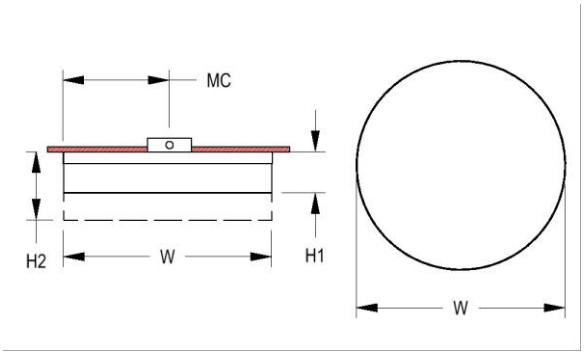
FEATURES & BENEFITS

- Diffuser available in two heights (see line art for details)
- Optional fabric lenses are cleanable
- Handcrafted in USA

SPECIFICATIONS

- **LIGHT SOURCE:** White LED light engine
- **LUMEN MAINTENANCE:** L70 = >50,000 Hrs.
- **CCT**: 3000K, 3500K, or 4000K
- **VOLTAGE:** 120-277V standard
- **DRIVER:** Integral Class II power supply standard
- **DIMMING:** 0-10V controls standard to 1% on LED light engines
- **DIFFUSER:** Choose matte opal or from four fabrics
- **MOUNTING:** Mounts to a standard 4" octagonal junction box
- **EMERGENCY:** Emergency battery remote optional
- **FINISH:** Tailor the mounting plate to your space. Choose from more than 30 thermoset polyester powder coat paint colors. RAL®, Pantone®, or custom finishes available upon request.
- **MODIFICATIONS:** Consult factory for all modification requests
- **APPROVALS:** ETL listed to UL standards (US & Canada) for use in damp locations; not recommended for exterior applications

DIMENSIONS



W	H1	H2	MC
36 in 91.4 cm	9.2 in 23.4 cm	13.2 in 33.5 cm	18 in 45.7 cm

Mounting Weight
Approximate: 40 lb (19 kg)

CONFIGURATOR

To configure your spec sheet online, go to www.spilighting.com/AIC11866. Not all options are available in all configurations; consult factory for details.

Required Field *

Catalog	Light Source*	Primary Finish*	Voltage*	Lamp Options*	Diffuser Height*	Diffuser Finish*	Emergency
AIC11866							
	A		B	C	D	E	F

A - LIGHT SOURCE *

To ensure color consistency, SPI uses precise bin selection and strict quality processes to maintain a 3-step (MacAdam) SDCM on all white LED lampings. Published LED luminaire wattages are calculated using a typical power supply efficiency of 88%; exact wattages may vary based on application.

☐ **L201W** | White 201W LED Light Engine| Delivered Lumens: 15,848
☐ **L100W** | White 100W LED Light Engine | Delivered Lumens: 7,924

See last page for finish options

B - VOLTAGE *

☐ **120-277V** | Universal Voltage

C - LAMP OPTIONS *

Delivered lumens shown are at 4000K CCT; apply multiplier for delivered lumens at other CCT.

☐ **3000K** [1] | 3000K CCT
☐ **3500K** [2] | 3500K CCT
☐ **4000K** | 4000K CCT

[1] Apply .95 multiplier for delivered lumens
[2] Apply .97 multiplier for delivered lumens

D - DIFFUSER HEIGHT *

Please choose one:

- ☐ **H07.5** | 7.5" Height
- ☐ **H11.5** | 11.5" Height

E - DIFFUSER FINISH *

Please choose one:

- ☐ **FB00** | Matte Opal Diffuser
- ☐ **FB01** | Fabric - Textured White Linen
- ☐ **FB02** | Fabric - Rapids
- ☐ **FB03** | Fabric - Chocolate Linen
- ☐ **FB05** | Fabric - Jute Linen

F - EMERGENCY

- ☐ **EMR** | Emergency Battery Remote

Available Finishes

Not all finishes are available in all configurations; consult factory for details.

Paint Colors

PT01 Super White	PT02 White	PT03 Morning Light	PT04 Warm White	PT05 Putty
PT06 Warm Beige	PT07 Light Taupe	PT08 Medium Taupe	PT09 Medium Grey	PT10 Dark Grey
PT11 Black	PT12 Dark Chocolate	PT13 Warm Grey	PT14 Light Grey	PT15 Sage
PT16 Spruce	PT17 Red	PT18 Deep Red	PT19 Blue	PT20 Dark Green
PT21 Pearl White (Metallic)	PT22 Platinum (Metallic)	PT27 Deep Copper (Metallic)	PT28 Dark Stainless (Metallic)	PT29 Red Brass (Metallic)
PT31 Medium Bronze (Metallic)	PT32 Dark Bronze (Metallic)	PT33 Dark Blue	PT40 Yellow	PT41 Orange
PT42 Sky Blue	PT43 Teal	PT44 Green	PT45 Purple	PT46 Aluminum (Metallic)
PT47 Deep Red Brass (Metallic)	PT48 Brass (Metallic)	PT49 Bronze (Metallic)	PT51 Matte White	

Novato Drum - Ceiling

AIC11865 24 in

SPI LIGHTING
PROJECT DETAILS

JOB NAME:
TYPE:
NOTES:

DESCRIPTION

While highly functional, the Novato family provides a playful twist to make a lasting impression. Versatility is the main strength of this collection as they are perfectly suited for a wide range of modern or traditional environments. Customize your visual environment with the Novato Drum by choosing a matte acrylic diffuser or from four fabric options. Available in 16", 24", 36", and 48" diameters.

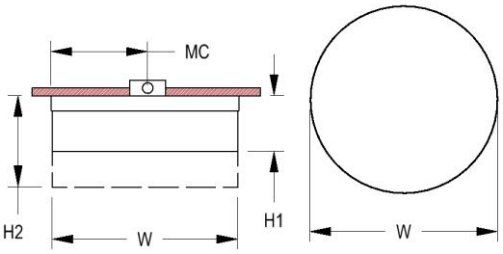
FEATURES & BENEFITS

- Diffuser available in two heights (see line art for details)
- Optional fabric lenses are cleanable
- Handcrafted in USA

SPECIFICATIONS

- **LIGHT SOURCE:** White LED light engine
- **LUMEN MAINTENANCE:** L70 = >50,000 Hrs.
- **CCT**: 3000K, 3500K, or 4000K
- **VOLTAGE:** 120-277V standard
- **DRIVER:** Integral Class II power supply standard
- **DIMMING:** 0-10V controls standard to 1% on LED light engines
- **DIFFUSER:** Choose matte opal or from four fabrics
- **MOUNTING:** Mounts to a standard 4" octagonal junction box
- **EMERGENCY:** Emergency battery remote optional
- **FINISH:** Tailor the mounting plate to your space. Choose from more than 30 thermoset polyester powder coat paint colors. RAL®, Pantone®, or custom finishes available upon request.
- **MODIFICATIONS:** Consult factory for all modification requests
- **APPROVALS:** ETL listed to UL standards (US & Canada) for use in damp locations; not recommended for exterior applications

DIMENSIONS



W	H1	H2	MC
24 in 61 cm	6.8 in 17.3 cm	11.8 in 30 cm	12 in 30.5 cm

Mounting Weight
Approximate: 20 lb (10 kg)

CONFIGURATOR

To configure your spec sheet online, go to www.spilighting.com/AIC11865. Not all options are available in all configurations; consult factory for details.

Required Field *

Catalog	Light Source*	Primary Finish*	Voltage*	Lamp Options*	Diffuser Height*	Diffuser Finish*	Emergency
AIC11865							
	A		B	C	D	E	F

A - LIGHT SOURCE *

To ensure color consistency, SPI uses precise bin selection and strict quality processes to maintain a 3-step (MacAdam) SDCM on all white LED lampings. Published LED luminaire wattages are calculated using a typical power supply efficiency of 88%; exact wattages may vary based on application. Alternative wattages available upon request.

- ☐ **L45W** | White 45W LED Light Engine| Delivered Lumens: 3,570
- ☐ **L89W** | White 89W LED Light Engine| Delivered Lumens: 7,140

See last page for finish options

B - VOLTAGE *

- ☐ **120-277V** | Universal Voltage

C - LAMP OPTIONS *

Delivered lumens shown are at 4000K CCT; apply multiplier for delivered lumens at other CCT.

- ☐ **3000K** [1] | 3000K CCT
- ☐ **3500K** [2] | 3500K CCT
- ☐ **4000K** | 4000K CCT

[1] Apply .95 multiplier for delivered lumens

[2] Apply .97 multiplier for delivered lumens

D - DIFFUSER HEIGHT *

Please choose one:

- ☐ **H05** | 5" Height
- ☐ **H10** | 10" Height

E - DIFFUSER FINISH *

Please choose one:

- ☐ **FB00** | Matte Opal Diffuser
- ☐ **FB01** | Fabric - Textured White Linen
- ☐ **FB02** | Fabric - Rapids
- ☐ **FB03** | Fabric - Chocolate Linen
- ☐ **FB05** | Fabric - Jute Linen

F - EMERGENCY

- ☐ **EMR** | Emergency Battery Remote

Available Finishes

Not all finishes are available in all configurations; consult factory for details.

Paint Colors

PT01 Super White	PT02 White	PT03 Morning Light	PT04 Warm White	PT05 Putty
PT06 Warm Beige	PT07 Light Taupe	PT08 Medium Taupe	PT09 Medium Grey	PT10 Dark Grey
PT11 Black	PT12 Dark Chocolate	PT13 Warm Grey	PT14 Light Grey	PT15 Sage
PT16 Spruce	PT17 Red	PT18 Deep Red	PT19 Blue	PT20 Dark Green
PT21 Pearl White (Metallic)	PT22 Platinum (Metallic)	PT27 Deep Copper (Metallic)	PT28 Dark Stainless (Metallic)	PT29 Red Brass (Metallic)
PT31 Medium Bronze (Metallic)	PT32 Dark Bronze (Metallic)	PT33 Dark Blue	PT40 Yellow	PT41 Orange
PT42 Sky Blue	PT43 Teal	PT44 Green	PT45 Purple	PT46 Aluminum (Metallic)
PT47 Deep Red Brass (Metallic)	PT48 Brass (Metallic)	PT49 Bronze (Metallic)	PT51 Matte White	

NOT USED

gotham® | INCITO™

Multiple Layers of Light

Luminaire Type:

Catalog Number:

High Center Beam Round Recessed Adjustable 4"

OVERVIEW

Feature Set

- Nine optimized distribution patterns allow designers to achieve tailored objectives
- Vertical tilt is self-locking from 0° - 40° with indicator arrow and gauge; 365° of horizontal rotation.
- Cut cones enable optimal efficacies while also occluding the inside of the fixture.
- Bounding Ray™ optical design
- 45° Cutoff to source and source image
- Field interchangeable optic
- Driver and LED light engine fully serviceable from below ceiling
- 70% lumen maintenance at 60,000 hours
- 2.5 SDCM; 85 CRI typical, 90+ CRI optional
- ENERGY STAR® Certified product

Distribution

Superior Performance

Nominal Lumens	500	750	1000	1500	2000	2500	3000	3500	4000	4500	5000
Delivered	618	710	934	1359	1739	2128	2569	3121	3503	3887	4265
Wattage	6.7	7.5	9.8	15.1	21.5	26.5	34.1	33.8	39.5	46.2	53.2
Efficacy	92	95	95	90	81	80	75	92	89	84	80

*Based on 3500K 80CRI 35D AR T00 LSS @ 0 Degrees

COMPLIMENTARY PRODUCTS

Coordinated Apertures | Multiple Layers of Light

General Illumination Layer | EVO

High Center Beam Layer | Incito

EVO + Incito — Multiple Layers of Light

Core

Healthcare

Special Applications

GOTHAM ARCHITECTURAL DOWNLIGHTING | 1400 Lester Road Conyers, GA 30012 | P 800-705-SERV (7378) | gothamlighting.com

ORDERING INFORMATION

A+ Capable options indicated by this color background.

Design2Ship Quick Ship Program: Options in green text qualify for Design2Ship — 5 business days from order entry to ship. Refer to Design2Ship Brochure for complete program details. **Maximum Order Quantity: 50 units.**

Luminaire Type:

Catalog Number:

EXAMPLE: ICO4ADJ 35/15 AR T00 LSS 35D 277 EZ1

Series		Color Temperature		Lumens		Reflector Color		Cut Cone		Reflector Finish		Beam	
ICO4ADJ	Incito 4in Round Recessed Adjustable	27/	2700 K	05	500 lumens	AR	Clear	T00	Cut for angles 0°-15°	LSS	Semi-specular	10D[2]	10° beam angle
		30/	3000 K	07	750 lumens	PR	Pewter	T30	Cut for angles 15°-30°	LD	Matte diffuse	15D	15° beam angle
		35/	3500 K	10	1000 lumens	WTR	Wheat	T40	Cut for angles 25°-40°			20D	20° beam angle
		40/	4000 K	15	1500 lumens	GR	Gold					25D	25° beam angle
		50/	5000 K	20	2000 lumens	WR[1]	White painted					30D	30° beam angle
				25	2500 lumens	BR[1]	Black					35D	35° beam angle
				30	3000 lumens	BZR[1]	Dark Bronze painted					40D	40° beam angle
				35	3500 lumens	WRAMF[1]	White Anti-microbial					45D	45° beam angle
				40	4000 lumens							50D	50° beam angle
				45	4500 lumens								
				50	5000 lumens								

Voltage		Driver		Control Interface		Options	
120	120V	GZ10	0-10V driver dims to 10%. Max: 3500LM	(blank)		SF	Single fuse.
277	277V	GZ1	0-10V driver dims to 1%. Max: 3500LM	NLT[7]	nLight® dimming pack.	90CRI	High CRI (90+)
347[3,4]	347V	EZ10	eldoLED 0-10V ECOdrive. Linear dimming to 10% min.	NLTER[7,8]	nLight® dimming pack for fixtures on emergency circuit	TRW[9]	White Painted Flange
		EZ1	eldoLED 0-10V ECOdrive. Linear dimming to 1% min.	NLTAIR2	nLight® AIR dimming pack.	TRBL[10]	Black Painted Flange
		EZB	eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%.	NLTAIRER2[8]	nLight® AIR dimming pack for fixtures on emergency circuit	CP[11]	Chicago Plenum
		EDAB[6]	eldoLED SOLOdrive DALI. Logarithmic dimming to <1%.	NLTAIREM2	nLight® AIR dimming pack for fixtures on emergency circuit	N80	nLight Lumen Compensation
		EDXB[5,6]	eldoLED POWERdrive DMX with RDM (remote device management). Square Law dimming to <1%. MIN:1000 MAX:4000			RRL___	RELOC® Ready Luminaire connectors enable a simple and consistent factory installed option across all ABL luminaire brands. Available only with RRLA, RRLB, RRLAE, and RRLC12S. Refer to RRL spec sheet on www.acuitybrands.com for RELOC® product specifications. Above ceiling access required.
		ECOS2[6]	Lutron® Hi-Lume® 2-wire forward-phase driver. 120V Only. Minimum dimming level 1%. Min: 1000LM; Max: 4000LM.				
		ECOD[6]	Lutron® EcoSystem® digital Hi-Lume 1% soft-on, fade to black. Min: 500LM; Max: 750LM.				

ACCESSORIES —order as separate catalog numbers (shipped separately)

OPTC4 XXD	Additional optics for field installation. Replace "XX" with beam angle.

ORDERING NOTES

1. Not Available with Finishes.
2. Only available 1500lm and below.
3. Not available with ELR emergency option.
4. Supplied with factory installed step down transformer.
5. Includes terminator resistor.
6. Not Available with Control Interfaces.
7. Must specify 120 or 277.
8. For use with generator supply EM power. Will require an emergency hot feed and normal hot feed.
9. For use with different reflector finish only (i.e. AR, PR, WTR, GR options). Not available with WR (White Reflector).
10. For use with different reflector finish only (i.e. AR, PR, WTR, GR options). Not available with BR (Black Reflector).
11. Only available up to 4500 lumens. Specify 120 or 277.

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

SPECIFICATIONS

Optical and Trim Assembly

Fully serviceable and upgradeable lensed LED light engine suitable for field maintenance or service from above or below the ceiling.

Optical design is a Bounding Ray™ design with 45° cutoff to source and source image. Top down flash characteristic for superior glare control.

Flangeless trim option includes proprietary Gotham mud ring enabling seamless integration into drywall applications. Mud ring ships separately.

Vertical tilt is self-locking from 0° - 40° with indicator arrow and gauge, engages with a manual tilt locking screw for added aiming assurance. Cut cones enable optimal efficacies while also occluding the inside of the fixture.

365° of horizontal rotation enabled through self-lubricating polymer which never binds or deforms. Cam lock locks rotation to ensure integrity of design throughout lifetime of luminaire.

Electrical

The luminaire shall operate from a 50 or 60 Hz ±3 Hz AC line over a voltage ranging from 120 VAC to 277 VAC. Support 347V via fixture-mounted stepdown transformer. The fluctuations of line voltage shall have no visible effect on the luminous output.

The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.

Sound Rated A+. Driver shall be >80% efficient at full load across all input voltages.

Input wires shall be 18AWG, 300V minimum solid copper.

Controls

Luminaire shall be equipped with interface for nLight wired or nLight AIR networks with integral power supply as per specification.

Emergency

Luminaires supplied with a battery pack comply with NFPA 101 (Life Safety code) and deliver constant light output throughout the 90 minutes of code required emergency operation period when there is a normal AC power loss with remote test switch available.

Dimming

The luminaire shall be capable of continuous dimming without perceivable stroboscopic flicker as measured by flicker index (ANSI/IES RP-16-10) over a range of 100 – 10%, 100 – 1.0% or 100 – 0.1% of rated lumen output with a smooth shut off function to step to 0%.

eldoLED LED drivers shall conform to IEEE P1789 standards. Alternatively, manufacturers must demonstrate conformance with product literature and testing which demonstrates this performance. Systems that do not meet IEEE P1789 will not be considered.

Driver is inaudible in 24dB environment, and stable when input voltage conditions fluctuate over what is typically experienced in a commercial environment.

Construction

Light engine and driver are accessible from above or below ceiling.

16-gauge black painted steel mounting frame with mounting bars included.

Post-installation adjustment possible from above or below ceiling.

Galvanized steel junction box with hinged access covers and spring latch. Three combination 1/2"-3/4" and one 1/2" knockout for straight-through conduit runs.

Capacity: 8 (4 in, 4 out) No. 12 AWG conductors rated for 90°C.

Accommodates up to 5/8"-thick ceilings.

Listings

Fixtures are CSA Certified to meet US and Canadian Standards: All fixtures manufactured in strict accordance with the appropriate and current requirements of the "Standards for Safety" to UL.

Luminaire configurations are Energy Star certified through testing in EPA–recognized laboratories, with the results reviewed by an independent, accredited certification organization. Visit www.energystar.gov for specific configurations listed.

IC-rated up to 1500 lumens.

Photometrics

LEDs tested to LM-80 standards. Measured by IESNA Standard LM-79-08 in an accredited lab. Lumen output shall not decrease by more than 30% over the minimum operational life of 60,000 hours.

Color appearance from luminaire to luminaire of the same type and in all configurations, shall be consistent both initially and at 6,000 hours and operate within a tolerance of <2.5 MacAdam ellipse as defined by the center of the quadrangles defined in ANSI C78.377-2015.

Warranty

5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/support/customer-support/terms-and-conditions

Note:

Actual performance may differ as a result of end user environment and application.
All values are design or typical values, measured under laboratory conditions at 25 °C.

A+ Capable Luminaire

This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight® control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

Tables of Use

ICO - eldoLED Driver Default Dimming Curve			
Nomenclature	Min Dimming	Driver Dim Curve	Control Dim Curve
EZ10	10%	Linear	Linear/Logarithmic
EZ1	1%	Linear	Linear/Logarithmic
EZB	<1%	Logarithmic	Linear
EDAB	<1%	Logarithmic*	Linear
EDXB	<1%	Square	Linear

*Changable thorugh DALI controller

Lumen Output Multiplier		
CRI	CCT	Multplier
80	2700K	0.916
	3000K	0.948
	3500K	1
	4000K	1.032
	5000K	1.1
90	2700K	0.748
	3000K	0.8
	3500K	0.838
	4000K	0.845
	5000K	0.945

Reflector Finish Multiplier	
Reflector Finish	Multiplier
LS - Specular	1
LSS - Semi Specular	0.956
WR - White	0.87
LD - Matte Diffuse	0.85
BR - Black	0.73
BZR - Bronze	0.73

Driver		Control Provided				
Nomenclature	Description	NLT	NLTER	NLTAIR2	NLTAIREM2	NLTAIRER2
GZ10	0-10V driver dims to 10%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V EM G2	RPP20 D 24V ER G2
GZ1	0-10V driver dims to 1%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V EM G2	RPP20 D 24V ER G2
EZ10	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V EM G2	RPP20 D 24V ER G2
EZ1	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V EM G2	RPP20 D 24V ER G2
EZB	eldoLED 0-10V SOLOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V EM G2	RPP20 D 24V ER G2

Marked Spacing in Inches 25°C Ambient			
Lumen Package	Fixed Center to Center MIN	Fixture Center to Building Member MIN	Space Above Fixture
3000-5000 (All driver options)	24	12	0.5

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CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

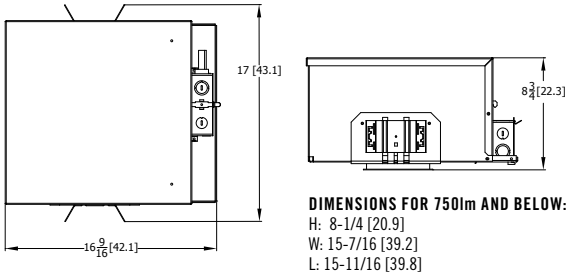
DIMENSIONAL DATA

*Dimensions in inches [centimeters]

Aperture: 4-5/16 [11] Ceiling Opening: 5-1/8 [13] self-flanged

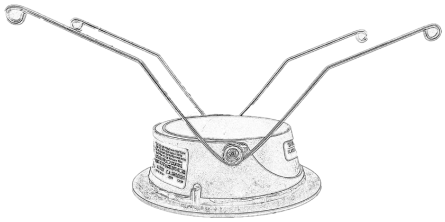
Overlap Trim: 5-7/16 [13.8]

Standard

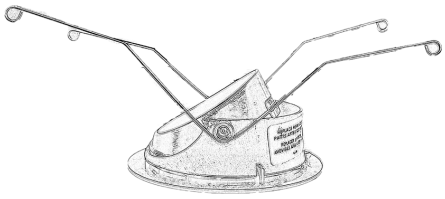


DIMENSIONS FOR 750lm AND BELOW:
H: 8-1/4 [20.9]
W: 15-7/16 [39.2]
L: 15-11/16 [39.8]

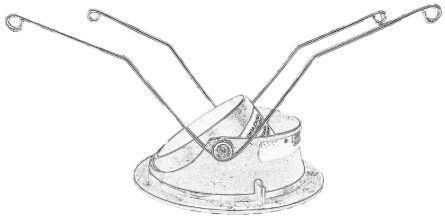
T00 Cut Cone for 0° - 15° Tilt



T30 Cut Cone for 15° - 30° Tilt



T40 Cut Cone for 26° - 40° Tilt



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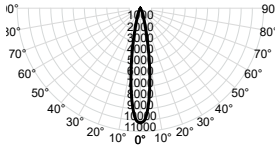
Photometry

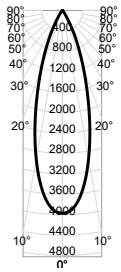
CONSULT WWW.GOTHAMLIGHTING.COM FOR ADDITIONAL PHOTOMETRY

ICO4ADJ 35/15 AR T00 LSS 15D at 0DEG Input Watts: 15.1, Delivered Lumens: 1399, LPW: 92.6, S/MH: 0.31, Test No: ISF 193855P101



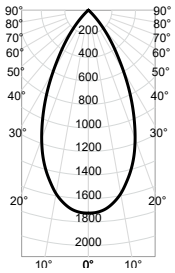
CP Summary		Zonal Lumen Summary			Coefficients of Utilization										Cone of Light			Luminance (cd/sq.m)	
					pf		80%			20%			50%		Mounting Height	Initial FC Center Beam	Beam Diameter		
	0°	Zone	Lumens	% Fixture	pc					70%									Average Luminance
					ρw	50%	30%	10%	50%	30%	10%	50%	30%	10%					
0°	10,241	0° - 30°	1,361	97%	0	119	119	119	116	116	116	111	111	111	6.0	284.5	1.9	0°	1,145,694
5°	8,467	0° - 40°	1,385	99%	1	113	112	110	111	110	108	107	106	105	8.0	160.0	2.6	45°	1,893
15°	1,688	0° - 60°	1,397	100%	2	109	106	104	107	105	103	104	102	100	10.0	102.4	3.2	55°	389
25°	381	0° - 90°	1,399	100%	3	105	101	99	103	100	98	101	99	97	12.0	71.1	3.9	65°	528
35°	34	90° - 180°	0	0%	4	101	98	95	100	97	94	98	95	93	14.0	52.2	4.5	75°	0
45°	12	0° - 180°	1,399	100%	5	98	94	92	97	94	91	96	93	91				85°	0
55°	2				6	95	92	89	95	91	89	93	90	88	Beam Angle: 18.4°				
65°	2				7	93	89	87	92	89	86	91	88	86	Field Angle: 36.2°				
75°	0				8	91	87	84	90	87	84	89	86	84					
85°	0				9	88	85	82	88	85	82	87	84	82					
90°	0				10	87	83	81	86	83	81	86	83	80					

ICO4ADJ 35/15 AR T00 LSS 30D at 0DEG Input Watts: 15.1, Delivered Lumens: 1264, LPW: 83.7, S/MH: 0.50, Test No: ISF 193858P101



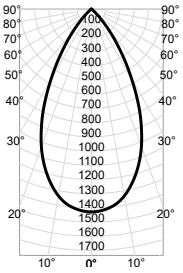
CP Summary		Zonal Lumen Summary			Coefficients of Utilization										Cone of Light			Luminance (cd/sq.m)	
					pf		80%			20%			50%		Mounting Height	Initial FC Center Beam	Beam Diameter		
	0°	Zone	Lumens	% Fixture	pc					70%									Average Luminance
					ρw	50%	30%	10%	50%	30%	10%	50%	30%	10%					
0°	3,974	0° - 30°	1,176	93%	0	119	119	119	116	116	116	111	111	111	6.0	110.4	3.2	0°	444,556
5°	3,713	0° - 40°	1,242	98%	1	112	110	109	110	108	107	106	105	104	8.0	62.1	4.3	45°	2,998
15°	2,013	0° - 60°	1,262	100%	2	107	103	101	105	102	100	102	99	97	10.0	39.7	5.4	55°	778
25°	637	0° - 90°	1,264	100%	3	101	98	94	100	97	94	98	95	92	12.0	27.6	6.5	65°	528
35°	90	90° - 180°	0	0%	4	97	93	89	96	92	89	94	90	88	14.0	20.3	7.6	75°	0
45°	19	0° - 180°	1,264	100%	5	93	88	85	92	88	85	90	87	84				85°	0
55°	4				6	89	84	81	88	84	81	87	83	80	Beam Angle: 30.3°				
65°	2				7	86	81	78	85	81	78	84	80	77	Field Angle: 55.8°				
75°	0				8	82	78	75	82	78	75	81	77	74					
85°	0				9	79	75	72	79	75	72	78	74	72					
90°	0				10	77	72	69	76	72	69	76	72	69					

ICO4ADJ 35/15 AR T00 LSS 45D at 0DEG Input Watts: 15.1, Delivered Lumens: 1244, LPW: 82.4, S/MH: 0.79, Test No: ISF 20509P101



CP Summary		Zonal Lumen Summary			Coefficients of Utilization										Cone of Light			Luminance (cd/sq.m)	
					pf		80%			20%			50%		Mounting Height	Initial FC Center Beam	Beam Diameter		
	0°	Zone	Lumens	% Fixture	pc					70%									Average Luminance
					ρw	50%	30%	10%	50%	30%	10%	50%	30%	10%					
0°	1,724	0° - 30°	944	76%	0	119	119	119	116	116	116	111	111	111	6.0	47.9	5.7	0°	192,883
5°	1,694	0° - 40°	1,173	94%	1	111	109	107	109	107	105	105	103	102	8.0	26.9	7.6	45°	10,886
15°	1,401	0° - 60°	1,242	100%	2	104	100	97	102	99	96	99	96	94	10.0	17.2	9.5	55°	972
25°	879	0° - 90°	1,244	100%	3	97	92	89	96	92	88	93	90	87	12.0	12.0	11.3	65°	528
35°	364	90° - 180°	0	0%	4	91	86	82	90	85	81	88	84	81	14.0	8.8	13.2	75°	0
45°	69	0° - 180°	1,244	100%	5	86	80	76	85	80	76	83	79	75				85°	0
55°	5				6	81	75	71	80	75	71	79	74	70	Beam Angle: 50.6°				
65°	2				7	76	71	67	76	70	66	74	70	66	Field Angle: 81.3°				
75°	0				8	72	67	63	72	66	63	71	66	62					
85°	0				9	69	63	59	68	63	59	67	62	59					
90°	0				10	65	60	56	65	59	56	64	59	56					

ICO4ADJ 35/15 AR T00 LSS 50D at 0DEG Input Watts: 15.1, Delivered Lumens: 1132, LPW: 75.0, S/MH: 0.84, Test No: ISF 193862P101



CP Summary		Zonal Lumen Summary			Coefficients of Utilization										Cone of Light			Luminance (cd/sq.m)	
					pf		80%			20%			50%		Mounting Height	Initial FC Center Beam	Beam Diameter		
	0°	Zone	Lumens	% Fixture	pc					70%									Average Luminance
					ρw	50%	30%	10%	50%	30%	10%	50%	30%	10%					
0°	1,429	0° - 30°	833	74%	0	119	119	119	116	116	116	111	111	111	6.0	39.7	6.1	0°	159,862
5°	1,407	0° - 40°	1,054	93%	1	111	109	106	109	107	105	105	103	101	8.0	22.3	8.1	45°	11,990
15°	1,206	0° - 60°	1,128	100%	2	103	100	96	102	98	95	99	96	93	10.0	14.3	10.2	55°	1,556
25°	810	0° - 90°	1,132	100%	3	97	92	88	95	91	87	93	89	86	12.0	9.9	12.2	65°	1,056
35°	352	90° - 180°	0	0%	4	91	85	81	89	84	81	87	83	80	14.0	7.3	14.2	75°	431
45°	76	0° - 180°	1,132	100%	5	85	79	75	84	79	75	82	78	74				85°	0
55°	8				6	80	74	70	79	74	70	78	73	69	Beam Angle: 53.9°				
65°	4				7	75	69	65	75	69	65	73	68	65	Field Angle: 83.5°				
75°	1				8	71	65	61	71	65	61	69	64	61					
85°	0				9	67	61	58	67	61	57	66	61	57					
90°	0				10	64	58	54	63	58	54	63	58	54					

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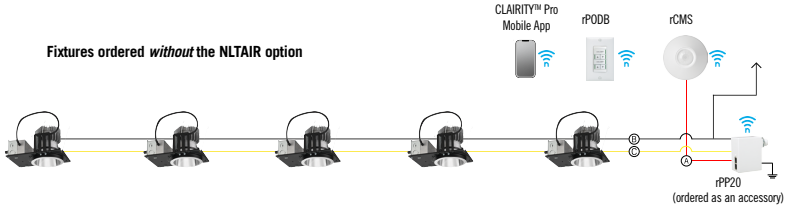
CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

NLIGHT AIR

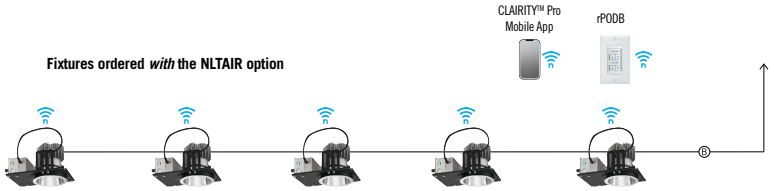
Possibilites for nLight® AIR

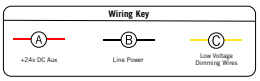
nLight® AIR is the ideal solution for retrofit or new construction spaces where adding communication wiring is cost prohibitive. The integrated nLight AIR rPP20 Power Pack is part of each EVO Luminaire ordered with the NLTAIR option. These individually addressable controls offer the ultimate in flexibility during initial setup and for space repurposing.

Fixtures ordered *without* the NLTAIR option



Fixtures ordered *with* the NLTAIR option





nLight® AIR Control Accessories
Order as separate catalog number. Visit nLight AIR.

Wall Switches	Model Number
On/Off single pole	rPODB (color) G2
On/Off two pole	rPODB 2P (color) G2
On/Off & raise/lower single pole	rPODB DX (color) G2
On/Off & raise/lower two pole	rPODB 2P DX (color) G2

nLight® AIR Control Accessories *(cont.)*

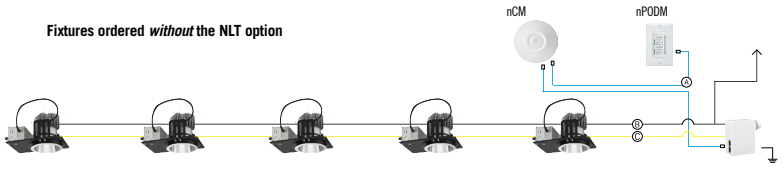
Occupancy Sensors (PIR/dual tech)	Model Number
Small motion 360°, ceiling	rCMS 9 / rCMS PDT 9
Large motion 360°, ceiling	rCMS 10 / rCMS PDT 10

NLIGHT

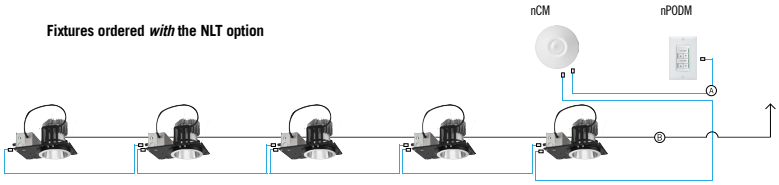
Possibilites for nLight® wired

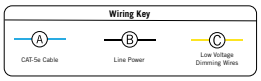
nLight® Wired The nLight® solution is a digital networked lighting control system that provides both energy savings and increased user configurability by cost effectively integrating time-based, daylight-based, sensor-based and manual lighting control schemes.

Fixtures ordered *without* the NLT option



Fixtures ordered *with* the NLT option





nLight® Wired Control Accessories
Order as separate catalog number. Visit nLight.

Wall Switches	Model Number
On/Off single pole	nPODM (XX)
On/Off two pole	nPODM 2P (XX)
On/Off & raise/lower single pole	nPOD DX (XX)
On/Off & raise/lower two pole	nPODM 2P DX (XX)
Graphic touchscreen	nPOD GFX (XX)
Photocell Controls	
Dimming	nCM ADCX

nLight® Wired Control Accessories *(cont.)*

Occupancy Sensors (PIR/dual tech)	Model Number
Small motion 360°, ceiling	nCM 9 / nCM PDT 9
Large motion 360°, ceiling	nCM 10 / nCM PDT 10
Wide View	nWV 16 / nWV PDT 16
Wall switch with raise/lower	nWSX LV DX / nWSX PDT LV DX
Cat-5 Cables (plenum rated)	
10', CAT5	CAT5 10FT J1
15', CAT5	CAT5 15FT J1

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NOT USED

GUIDE
WS33407

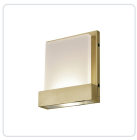
WALL

PROJECT

WS33407-BN
Brushed Nickel

WS33407-BK
Black

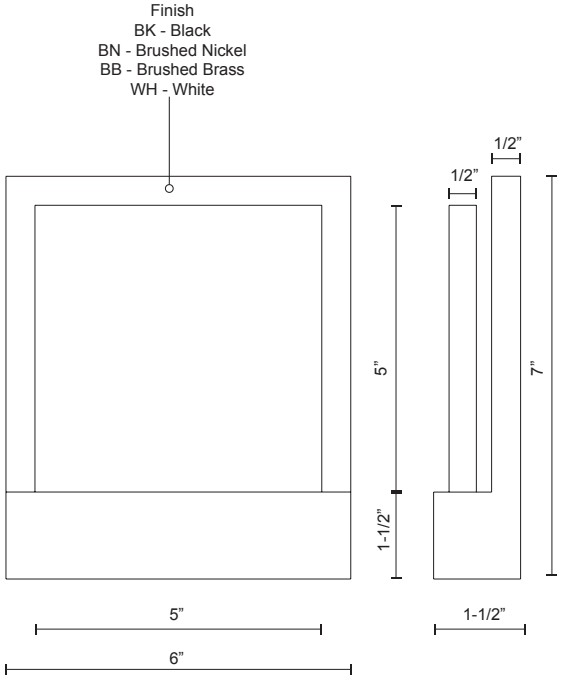
WS33407-WH
White



WS33407-BB
Brushed Brass

DESCRIPTION

Implementing an edge-lit LED optical assembly results in a singular plane of diffusive glowing luminance. The GUIDE interior wall lamp obscures the radiant source within a precision-machined aluminum body. Slightly offset from the wall the orthogonal reductive fixture provides an optimal architectural accent. Custom patterns or text may replace the uniform translucence of the light guide.



SPECIFICATION DETAILS

* For custom options, consult factory for details.

Fixture Dimensions	W6" x H7" x E1-1/2"
Light Source	LED
Wattage	7W
Total Lumens	500lm*
Delivered Lumens	BK-275lm
Voltage	120V
Color Temperature	3000K
CRI (Ra)	>90
Optional Color Temps	2700K - 5000K Available, Minimum Order Quantities Apply
LED Rated Life	50,000 hours
Dimming	100% - 10%, ELV Dimmer (Not Included)
Diffuser Details	Frosted Glass Diffuser
Shade Details	Heavy Frosted Acrylic
Location	Dry
Warranty	5 Years
ADA Compliant	Yes

KUZCO

19054 28TH AVENUE
SURREY - BC V3Z 6M3
CANADA

WWW.KUZCOLIGHTING.COM

COMMENT

Intertek

MARK
ARCHITECTURAL
LIGHTING™

The **SPR LED** Series

SPR LED combines the environmental and cost-saving benefits of solid-state lighting with the popular SP design. The result is a recessed linear wall product that provides an excellent balance of efficiency and performance.

SPR LED, which features a very compact profile, offers highly uniform illumination along wall surfaces. Housing and vertical fascias are extruded aluminum, and the extruded clear frosted acrylic lens snaps into the housing. SPR LED is available in 8-, 7-, 6-, 5-, 4-, 3-, and 2-foot sections. Corners are available; please consult factory.

Type:

Project:

Catalog Number:

DO NOT TYPE HERE. Autopopulated field.

Specification Features (continued on page 2)

Housing
Housing and vertical fascias are extruded aluminum. Internal wiring trays are 20-gauge, cold-rolled steel.

Housing Finish
Natural Aluminium; Fascia is high reflectance matte white .

Shielding
Extruded clear frost acrylic lens snaps into housing.

Mounting
Recessed perimeter wall wash in 8', 7', 6', 5', 4', 3', and 2' sections.

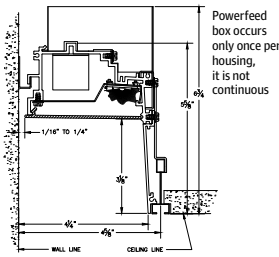
Fixture Performance - SPRL

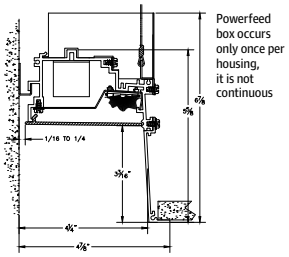
Lumens Output	400 LMF	600 LMF	800 LMF	1000 LMF
Delivered Lumens (l/ft)	367	632	856	1078
Input Watts	3.4	5.8	8.0	10.5
Lumen/Watt	106.8	108.8	106.7	102.8

Results based on a 4FT 80CRI 35K luminaire.
Consult factory for customized lumen and wattage based on calculated values.

A+ Capable options indicated by this color background.

Technical Drawings





Ordering

Example: SPRLED LOP 24FT6.50 RLP G9 80CRI 35K 800LMF MIN1 MVOLT ZT

Series
SPRLED Fully Recessed SP LED

Linear Plan
LOP Linear Optimized Plan

Total Run Length[1]
_FT_-_ Provide wall-to-wall dimension to nearest 1/4" (Example 24' - 6 1/2" = 24FT6.50)

Fixture Style
RLP Regressed Lens

Ceiling Trim
G9 9/16" wide inverted tee
FL 5/8" flange (sheetrock)

Direct Light Source CRI
80CRI 80CRI
90CRI 90CRI

Direct LED Color Temperature
30K 3000K
35K 3500K
40K 4000K

Direct LED Light Output
400LMF 400 lumens per foot
450LMF 450 lumens per foot
600LMF 600 lumens per foot
800LMF 800 lumens per foot
1000LMF 1000 lumens per foot

Minimum Dimming Level
NODIM[2] No Dimming
MIN1 Constant current, dimming to 1%
DARK Constant current, dimming to <1%

Voltage
MVOLT MVOLT
120 120 volt
277 277 volt

Emergency Options
(blank) No emergency
_RE10W Number of emergency sections with remote battery pack
EMG[3] Sections with emergency nLight device for use with generator supply EM power
_EC[4] # of Emergency Circuits

Control Input
(blank) No control input. For use with non-dimming
DALI DALI
ECO Lutron Ecosystem Interface Module
ECOD[5] Lutron Ecosystem Driver
NLIGHT nLight enabled
ZT 0-10V

Option Group
CP Chicago plenum
PWS 6' pre-wire, 3/8" diameter, 18 gauge

Notes
1. Provide field dimensions for patterns, clearly indicating inside or outside corners. Patterns are made to size and are not field adjustable. Upon request factory will prepare installations drawing for approval.
2. If NODIM is selected, do not select a value from the control input category.
3. Must select NLIGHT option.
4. 5' & 6' sections get 3' on EC. 4', 7' & 8' get 4' on EC.
5. ECOD when combined with MIN1 incorporates an Ecosystem H-Series 1% dimming driver.

Specification Features (continued)

LED Life
Rated 50,000 hours (L80) at 25° C ambient temperature.

Color Consistency
The Acuity Brands circuit boards for the linear LED components use a precise binning algorithm which creates a consistent color temperature from board to board. Color variation is no greater than a 2.5 Step MacAdam (2.5SDCM) along the black body locus from board to board.

Integrated Controls
Optional nLight® embedded controls make luminaire addressable- allowing it to digitally communicate with other nLight enabled controls such as dimmers, switches, occupancy sensors and photocontrols. Simply connect all the nLight enabled control devices using standard CAT5 Cabling. (Option: NLIGHT)

A+ Capable Luminaire
This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

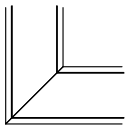
- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

Certification
CSA tested to UL 1598 standards, rated for Chicago Plenum.

Corners
Patterns can be configured in 1' increments with illuminated 90° inside or outside corners, with standard 2' corner junction lengths. For custom angles, corner or junction lengths, consult factory.



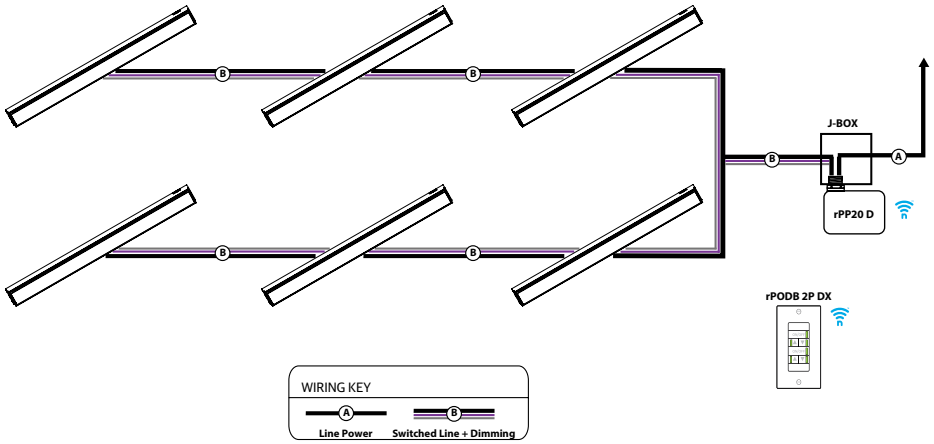
90° Corner

Warranty
5-year limited warranty. Complete warranty terms located at:
www.acuitybrands.com/support/customer-support/terms-and-conditions
Note: Actual performance may differ as a result of end-user environment and application. All values are design or typical values, measured under laboratory conditions at 25 °C. Specifications subject to change without notice.

nLight Air Wireless

To Make fixture NLTAIR2 compatible the following components are required:

1) rpp20 D
2) rPODB 2P DX



MARK
ARCHITECTURAL
LIGHTING™

The **Whisper LED** Series

Gently sloping side panels give Whisper LED its depth and appealing angles. Whether units are installed in rows or individually, the look is artfully clean and simple.

Multiple lens options for the center panels allow you to achieve the appropriate design and illumination for each space. Whisper LED is available in 1' x 4', 2' x 2' and 2' x 4' sizes, and it fits perfectly in a variety of business and institutional settings including offices, schools and hospitals.

Type:

Project:

Catalog Number:

DO NOT TYPE HERE. Autopopulated field.

Specification Features (continued on page 2)

Housing
Nominal 1'x4', 2'x2' or 2'x4' housings fabricated from 22-gauge, cold-rolled steel.

Finish
Matte-white powder coat.

Reflector
Precision-formed steel; highly reflective white.

Shielding
Hinged door frame is constructed of extruded aluminum center and side rails with cold-rolled steel end caps capturing the 3 individual optical panels, forming a single unit. The frame can be positioned on either side of the fixture housing to provide easy room side access for maintenance. Shielding options are as follows:
Center Panel: Soft-white acrylic or optional microprismatic conical de-glaring lens.
Side Panels: Soft-white acrylic.

A+ Capable options indicated by this color background.

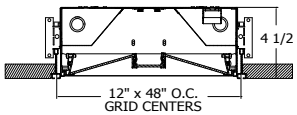
Mounting
Accommodates 9/16" slot grid or 15/16" inverted tee or 9/16" inverted tee.

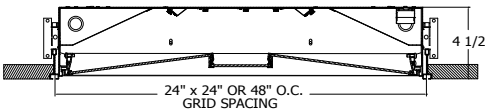
For recessed mounting in hard ceiling applications, use a Drywall Grid Adapter (DGA22, DGA24, or DGA14WHS). Ordered separately.

Shipping
5-10 business days from clean release.

See WHSPR QS spec sheet for 5 day shipping configurations.

Technical Drawings





Ordering

Example: WHSPR 2X4 4800LM 35K 80CRI MIN1 NLIGHT MVOLT PDT ADC SWC

Series	Size	LED Output[1]	LED Color Temp	LED Color Rendering	Minimum Dimming Level	Control Input
WHSPR Whisper LED	**2X2** 2' x 2'	**2000LM**[2] 2000 Lumens	**30K** 3000K	**80CRI** >80 CRI	**NODIM**[9] Non-dimming	**(blank)** No control input. For use with non-dimming
	2X4 2' x 4'	**3000LM**[3] 3000 Lumens	**35K** 3500K	**90CRI** >90 CRI	**MIN10**[22] 10% Minimum Dimming	**ZT** 0-10v
	1x4 1' x 4'	**3300LM**[4] 3300 Lumens	**40K** 4000K		**MIN1** 1% Minimum Dimming	**NLIGHT**[10] nLight Enabled
		4000LM 4000 Lumens	**50K** 5000K		**DARK** <1% Minimum Dimming	**NLTAIR2**[11] nLight Air (wireless) Enabled
		4800LM[5] 4800 Lumens				**DALI**[12] DALI compatible
		6000LM[6] 6000 Lumens				**DMX**[12,13] DMX compatible
		7200LM[7] 7200 Lumens				**ECOD**[14] Lutron Ecosystem Driver
		8500LM[8] 8500 Lumens				

For additional ordering assistance consult 'Intelligent Luminaire Technology Guide'.

Voltage	Primary Sensors[15]	Shielding Center	Options	
MVOLT MVOLT	**(blank)** No Sensor	**SWC** Soft White Acrylic	**E10WLCP**[16] 10 Watt battery pack, constant power with self diagnostic. T20 Compliant.	**PWS1846 PWSLV**[20] Two cables: one 6' pre-wire, 3/8" diameter, 18 gauge, 2 circuits; one 6' pre-wire, 3/8" diameter, 18 gauge, purple and gray
120 120V	**PIR** Occupancy Sensor- Passive Infrared	**YBC** Microprismatic Conical Deglaring Lens	**EMG**[17] Emergency nLight device for use with generator supply EM power	**PWS1856LV**[20] 6' pre-wire, 3/8" diameter, 18 gauge, 1 circuit w/low voltage purple and grey wires
277 277V	**PDT** Occupancy Sensor- Dual Technology (Passive Infrared & Microphonics)		**BGTD**[18] Generator Transfer Device	**GLR**[21] Fast-blow Fuse
347 347V	**API** PIR Occupancy Sensor & Photocell		**AMF** Antimicrobial Finish	**GMF**[21] Slow-blow Fuse
	APD PDT Occupancy Sensor & Photocell		**CP**[19] Chicago Plenum	**LATC** Earthquake Clips
	For additional ordering assistance consult 'Intelligent Luminaire Technology Guide'.		**PWS1836** 6' pre-wire, 3/8" diameter, 18 gauge, 1 circuit	**USPOM** US point of assembly
			PWS1846 6' pre-wire, 3/8" diameter, 18 gauge, 2 circuit	

For footnotes, see page 2.

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

Specification Features (continued)

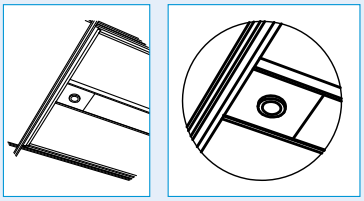
Source
Static LED: 3000K, 3500K, 4000K, 5000K; standard CRI >80 with optional >90

LED Life
Rated 60,000 hours (L80) at 25° C ambient temperature.

Color Consistency
The Acuity Brands circuit boards with color a variation of no greater than a 2.5 Step MacAdam (2.5SDCM) along the black body locus from board to board.

Driver
eldoLED constant current driver options deliver choice of dimming range for ultra-smooth dimming resolution from 100% to less than 1% , and choices for control, while assuring flicker free, low current inrush, 89% efficiency and low EMI. Generic 10% dimming driver also available for MIN10 option.
Two drivers used for lumen packages over 4800LM.
Consult 'Intelligent Luminaire Technology Guide' for additional details.

Integrated Controls
Optional nLight® embedded controls make luminaire addressable- allowing it to digitally communicate with other nLight enabled controls such as dimmers, switches, occupancy sensors and photocontrols. Simply connect all the nLight enabled control devices using standard CAT5 Cabling.
Consult 'Intelligent Luminaire Technology Guide' for additional details.



Pictured with Occupancy Sensor and Photocell

Maintenance
Serviceable from below with easy access to electrical components.

A+ Capable Luminaire
This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

Certification
CSA Certified to meet U.S. and Canadian standards, CSA Certified for damp locations, IC-rated, optional Chicago plenum rating available.
DesignLights Consortium® (DLC) qualified product. Not all versions of this product may be DLC qualified. Please check the DLC Qualified Products List at www.designlights.org/QPL to confirm which versions are qualified.

Warranty
5-year limited warranty. Complete warranty terms located at:
www.acuitybrands.com/CustomerResources/Terms_and_conditions.aspx

Note: Actual performance may differ as a result of end-user environment and application.

All values are design or typical values, measured under laboratory conditions at 25 °C.

Specifications subject to change without notice.

* Applies to eldoLED driver configurations.

Notes
1. Nominal values. Consult Fixture Performance table for actual delivered lumens.
2. 2000LM output valid for 2x2 and 1x4 sizes. Not available with MIN10 driver.
3. 3000LM output valid for 2x4 size. Not available with MIN10 option.
4. 3300LM output valid for 2x2 and 1x4 sizes.
5. 4800LM not available with MIN10 in 2x2 or 1x4, only with 2x4.
6. 6000LM output valid for 2x4 and 1x4 sizes. Not available with MIN10 driver.
7. 7200LM output valid for 2x4 and 1x4 sizes. Not available with MIN10 driver.
8. 8500LM output valid for 2x4 size. Not available with MIN10 driver.
9. If NODIM is selected, do not select a value from the Control Input category.
10. NLIGHT only available with MIN1 or DARK dimming.
11. NLTAIR2 not available with 1x4. Must select MIN1 or DARK. If sensor required must select API or APD.
12. Only available with DARK dimming.
13. DMX not available with lumen packages over 4800LM
14. ECO only available with MIN1 dimming.
15. Not available with 1x4 or MIN10 driver. Only available with ZT or NLIGHT control inputs. If paired with ZT, sensor will be integral but not nLight enabled. All sensors are factory-installed onboard sensors. PIR and PDT only available with NLIGHT.
16. Not available with 6000LM, 7200LM, or 8500LM lumen packages. Test switch located on internal reflector behind diffuser. Glow of test switch visible from below.
17. nLight EMG option requires a connection to existing nLight network. Power is provided from a separate nLight cabled fixture.
18. Must select 120 or 277 option, not available with E10WLCP option.
19. CP not available with NLIGHT option.
20. Pre-wire whips with low voltage leads not valid with non-dimming (NODIM) fixtures or NLIGHT.
21. Voltage must be specified 120 or 277.
22. Must select ZT.

Fixture Performance

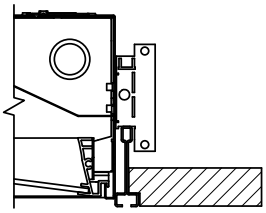
		Delivered Lumens	Input Watts	Lumens/ Watt
2x2	**2000LM**	2072	17.6	118
	3300LM	3451	29.8	116
	4000LM	4222	37.4	113
	4800LM	4964	45.4	109
2x4	**3000LM**	3085	25.4	121
	4000LM	4076	33.8	121
	4800LM	4879	41.2	118
	6000LM	6086	52.9	115
	7200LM	7315	65	113
	8500LM	8573	77.9	110
1x4	**2000LM**	2065	19.1	108
	3300LM	3341	31.5	106
	4000LM	4046	39.6	102
	4800LM	4923	48.3	102
	6000LM	6142	57.3	107
	7200LM	7268	69.9	104

**Results at 3500K, 80CRI, with SWC center shielding option.*

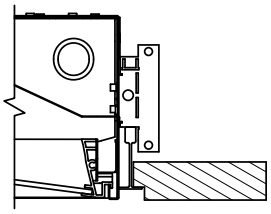
How to Calculate Delivered Lumens in Emergency Mode
Use the formula below to determine the delivered lumens in emergency mode
Delivered Lumens = 1.25 x P x LPW
P = Ouput power of emergency driver. P = 10W for E10WLCP option.
LPW = Lumen per watt rating of the luminaire. This information is available on the ABL luminaire spec sheet. LPW = Lumen per watt rating of the luminaire. LPW information available in Performance Data section.

Mounting

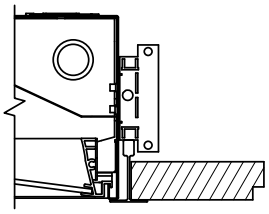
Recessed, lay-in formed steel trim. Universal trim accommodates 9/16" slot grid or 15/16" inverted tee, or 9/16" inverted tee.



UNIV
(9/16" Slot Grid)



UNIV
(9/16" Grid)

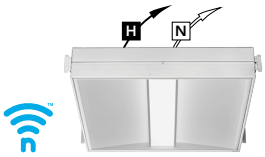


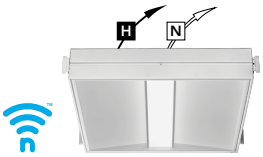
UNIV
(15/16" Grid)

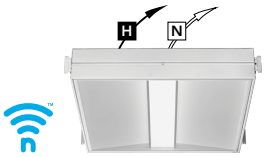
For recessed mounting in hard ceiling applications, use one of the following drywall grid adapters (ordered separately).

Fixture	Drywall Grid Adapter (DGA)
WHSPR 2X2	DGA22
WHSPR 2X4	DGA24
WHSPR 1X4	DGA14WHS

nLight Air Wireless







Simple as 1,2,3

1. Install the nLight® AIR fixtures with embedded smart sensor
2. Install the wireless battery-powered wall switch
3. With our CL***AIR***ITY app, pair the fixtures with the wall switch and if desired, customize the sensor settings for the intended outcome

rPODB 2P DX WH G2

Mobile Device

Intelligent Luminaire Technology Guide

Choose nomenclature from these columns

Driver Configurations for Whisper

Minimum Dimming Level		Control Input		Driver	Dimming Range	Notes
NODIM	+	(blank)	=	0 10V Generic Driver	-	Includes no 0 10V leads from the driver.
MIN10	+	ZT	=	0 10V Generic Driver	100 to 10%	Linear dimming
MIN1	+	ZT	=	0 10V eldoLED ECOdrive	100 to 1%	Formerly (EZ1) nomenclature. Linear dimming
MIN1	+	NLIGHT	=	0 10V eldoLED ECOdrive	100 to 1%	Linear dimming
MIN1	+	ECOD	=	Lutron Digital Ecosystem (LDE1 Series)	100 to 1%	Hi-lume 1% EcoSystem LED driver with Soft-on, Fade-to-Black. Formerly (EES1) nomenclature.
DARK	+	ZT	=	0 10V eldoLED SOLOdrive	100 to 0.1%	Formerly (EZB) nomenclature. Logarithmic dimming
DARK	+	NLIGHT	=	0 10V eldoLED SOLOdrive	100 to 0.1%	Logarithmic dimming
DARK	+	DALI	=	DALI compatible eldoLED SOLOdrive	100 to 0.1%	Compatible with DALI. Formerly (EDB & EDAB) nomenclature. Logarithmic dimming
DARK	+	DMX	=	DMX compatible eldoLED POWERdrive	100 to 0.1%	Compatible with DMX / Remote Device Management. Formerly (EXB & EDXB) nomenclature.

Choose nomenclature from these columns

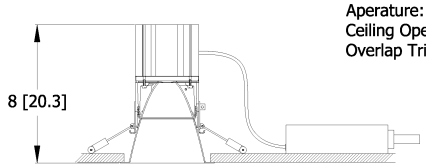
Control / Sensor Configurations for Whisper

Control Input		Sensor		Sensor	Notes
ZT	+	API	=	MSD 7 ADCX	Individual fixture control only. PIR integral occupancy sensor with automatic dimming control photocell. (Old nomenclature: ZT + PIR + ADC)
ZT	+	APD	=	MSD PDT 7 ADCX	Individual fixture control only. PDT integral occupancy sensor with automatic dimming control photocell. (Old nomenclature: ZT + PDT + ADC)
NLIGHT	+	(blank)	=	nIO EZ PH	nLight enabled only. No onboard sensor.
NLIGHT		EMG	=	nIO EZ PH ER	Emergency nLight enabled only. No onboard sensor.
NLIGHT	+	PIR	=	nIO EZ PH + nES 7	nLight nES 7 PIR integral occupancy sensor. (Old nomenclature: NLIGHT + PIR)
NLIGHT	+	API	=	nIO EZ PH + nES 7 ADCX	nLight nES 7 ADCX PIR integral occupancy sensor with automatic dimming photocell. (Old nomenclature: NLIGHT + PIR + ADC)
NLIGHT	+	PDT	=	nIO EZ PH + nES PDT 7	nLight nES PDT 7 dual technology integral occupancy sensor. (Old nomenclature: NLIGHT + PDT)
NLIGHT	+	APD	=	nIO EZ PH + nES PDT 7 ADCX	nLight nES PDT 7 dual technology integral occupancy sensor with automatic dimming photocell. (Old nomenclature: NLIGHT + PDT + ADC)
NLTAIR2		(blank)		RIO EZDL 90D G2	https://www.acuitybrands.com/products/detail/778845/nLight/rIO/Fixture-embedded-nLight-AIR-network-interface
NLTAIR2		API		RES7 G2	https://www.acuitybrands.com/products/detail/593899/nLight/RES7 Sensor/nLight-AIR-Fixture-Integrated-Wireless-Sensor
NLTAIR2		APD		RES7 PDT G2	https://www.acuitybrands.com/products/detail/593899/nLight/RES7 Sensor/nLight-AIR-Fixture-Integrated-Wireless-Sensor

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

gotham®

Luminaire Type:
Catalog Number (autopopulated):



Aperature: 4-5/16 [11]
Ceiling Opening: 5 [12.7]
Overlap Trim: 5-11/16 [13.8]

Gotham Architectural Downlighting
LED Downlights

4" Incito IFB®
Downlight

Solid-State Lighting
(US and International Patents Pending)

FEATURES

OPTICAL SYSTEM

- Eleven optimized distribution patterns allow designers to achieve tailored effects.
- Self-flanged semi-specular or matte-diffuse, metal-clad lower reflector utilized in combination with a highly transmissive lens.
- Patented Bounding Ray™ Optical Principle design (U.S. Patent No. 5,800,050) provides smooth and continuous transition from lensed source to the top of the reflector down to the bottom of the reflector.
- Field interchangeable optics.

MECHANICAL SYSTEM

- Light engine and driver are accessible from below ceiling.
- install from below mounting springs
  Post-installation adjustment possible from below ceiling.
- Galvanized steel driver junction box with hinged access covers and spring latch. 1/2" knockout for straight-through conduit runs. Capacity: 4 (2 in, 2 out) No. 12 AWG conductors rated for 90°C.
- Accommodates up to 1½"-thick ceilings.

ELECTRICAL SYSTEM

- Solid-state LED light engine available in 2700 K, 3000 K, 3500 K or 4000 K color temperatures. CRI: 85 typical
- eldoLED ecoDrive 0-10V driver available with 10% dimming level.
- eldoLED ecoDrive 0-10V driver available with 1% dimming level.
- eldoLED SOLOdrive 0-10V driver available with <1% dimming level.
- eldoLED SOLOdrive DALI driver available with <1% dimming level.
- >70% lumen maintenance at 60,000 hours.
- Tested in accordance with LM-79 and LM-80 standards.

LISTINGS

- Fixtures are CSA certified to meet US and Canadian standards; wet location, covered ceiling, (Pending).

WARRANTY

- 5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/CustomerResources/Terms_and_conditions.aspx

Note: Actual performance may differ as a result of end user environment and application. All values are design or typical values, measured under laboratory conditions at 25 °C.

ORDERING INFORMATION

EXAMPLE: ICOI 30/20 4AR LD 20D 120 EZB

Series	Color temperature	Nominal delivered lumen values		Aperture/ Trim color	Trim Style	Finish	Beam	
ICOI	**27/** 2700 K	**05** 500 lumens	**25** 2500 lumens	**4AR** Clear	(blank) Self-flanged	**LSS** Semi-specular	**10D** 10° beam angle	**40D** 40° beam angle
	30/ 3000 K	**07** 750 lumens	**30** 3000 lumens	**4PR** Pewter		**LD** Matte diffuse	**15D** 15° beam angle	**45D** 45° beam angle
	35/ 3500 K	**10** 1000 lumens	**35** 3500 lumens	**4WTR** Wheat			**20D** 20° beam angle	**50D** 50° beam angle
	40/ 4000 K	**12** 1250 lumens	**40** 4000 lumens	**4WR**[1] White			**25D** 25° beam angle	**60D** 60° beam angle
		15 1500 lumens	**45** 4500 lumens	**4BR**[1] Black			**30D** 30° beam angle	**65D** 65° beam angle
		20 2000 lumens					**35D** 35° beam angle	

Voltage	Driver	Options
120	**EZ10** eldoLED 0-10V ECOdrive. Linear dimming to 10% min.	**TRW**[2] White painted flange
277	**EZ1** eldoLED 0-10V ECOdrive. Linear dimming to 1% min.	**TRBL**[3] Black painted flange
	EZB eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%.	**CRI90** High CRI (90+)
	EDAB eldoLED SOLOdrive DALI. Logarithmic dimming to <1%.	

ACCESSORIES order as separate catalog numbers (shipped separately)	
OPTC4[8]	Additional optics for field installation.

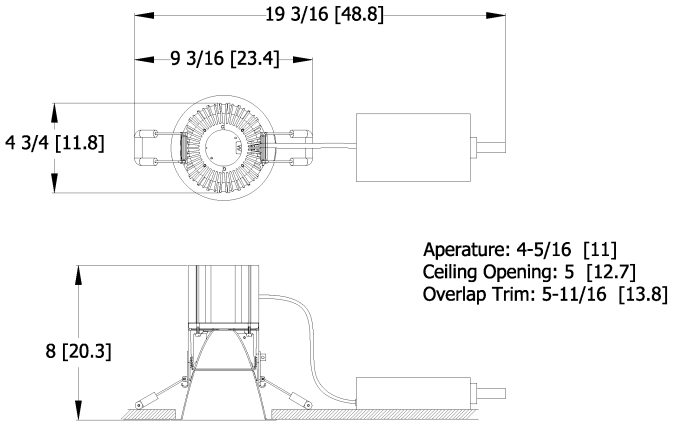
GOTHAM ARCHITECTURAL DOWNLIGHTING | P 800.315.4982 | gothamlighting.com

PRELIMINARY

gotham®

DIMENSIONAL DATA

All dimensions are inches (centimeters) unless otherwise noted.



ELECTRICAL

WATTAGE CONSUMPTION MATRIX	
NOMINAL DELIVERED LUMENS	**Wattage**
4500	50 W
4000	43 W
3500	36 W
3000	39 W
2500	33 W
2000	23 W
1500	17 W
1250	12 W
1000	10 W
750	7 W
500	6 W

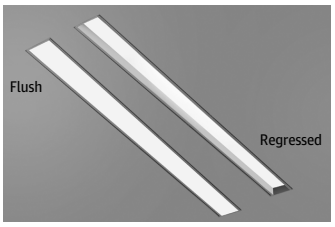
NOTES

ORDERING NOTES

1. Not available with finishes.
2. Not required for WR reflector.
3. Not required for BR reflector.
8. Must specify desired optical distribution from available options in "Beam" option column in the ordering tree. i.e. OPTC4 20D.

MARK ARCHITECTURAL LIGHTING™

Slot 4 LED
Recessed Linear



Slot 4 LED takes both form and function a step further with increased efficacy and integral controls creating a digitally addressable luminaire that is perfect where visually harmonious illumination and energy efficiency are desired.

Slot 4 LED is the ideal choice for spaces that emphasize lines and clean contemporary design. It is a perfect fit for Armstrong TechZone™ ceiling systems. A regressed lens option provides added dimension to the sleek, slender design and the flush lens now has a Wet Label option.

Type:

Project:

Catalog Number:

DO NOT TYPE HERE. Autopopulated field.

Specification Features (continued on page 2)

Housing
Nominal 4" x 2', 3', 4', 5', 6', 7', 8' and continuous rows in 1" increments as standard, upper housing fabricated from cold-rolled steel with extruded aluminum ceiling trim.

Finish
Painted high reflectance matte white powder coat.

Reflector
Precision-formed steel; high reflectance matte white powder coat; 93% reflectivity.

Shielding
Flush Lens: Snap-in 90% transmissive satin acrylic lens.

Regressed Lens: Lay-in 90% transmissive satin acrylic lens.

Mounting
Recessed. Available for sheetrock, 9/16" slot grid or 15/16" inverted tee ceilings, or 9/16" inverted tee.

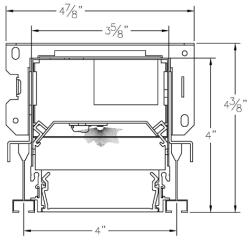
Fixture Performance - SL4L*

Lumens Output	400 LMF		600 LMF**		800 LMF**		1000LMF	
Fixture Style	RLP	FLP	RLP	FLP	RLP	FLP	RLP	FLP
Delivered Lumens/FT	316	314	544	541	737	734	928	924
Input Watts/FT	4	4	6	6	8	8	10	10
Lumen/Watt	91	91	95	95	93	93	90	89

*CCT (35K)
*Consult factory for customized lumen output and wattage
**Based on calculated values

A+ Capable options indicated by this color background.

Technical Drawing



Flush - (FLP)

Ordering

Example: SL4L LOP 4FT FLP TG 90CRI 35K 400LMF S80CRI S27K E10WLCP NLIGHT WL USPOM

Series
- **SL4L** Slot 4 LED Linear Recessed

Linear Length Plan
- **LOP** Linear Optimized Plan

Total Run Length
- **2FT** 2'
- **3FT** 3'
- **4FT** 4'
- **5FT** 5'
- **6FT** 6'
- **7FT** 7'
- **8FT** 8'
- **_FT_** *Specify continuous linear feet in 1" increments (7FT6 = 7FT 6IN)

Fixture Style
- **RLP**[1] Regressed Lens
- **FLP**[2,3] Flush Lens

Ceiling Trim
- **FL**[4] 5/8" Flange(sheetrock)
- **TG** 9/16" or 15/16" Flat or Inverted Tee
- **GB**[4] Trimless (sheetrock)
- **WFL** Perimeter Mount, 5/8" Flange (Sheetrock)
- **WTG** 9/16" Flat or Inverted Tee, Perimeter Mount

Direct Light Source Color Rendering
- **80CRI** 80 CRI
- **90CRI** 90 CRI

Direct LED Color Temp
- **27K*** 2700K
- **30K** 3000K
- **35K** 3500K
- **40K** 4000K
- **50K*** 5000K

Direct LED Light Output
- **400LMF** 400 Lumens per FT
- **600LMF** 600 Lumens per FT
- **800LMF** 800 Lumens per FT
- **1000LMF** 1000 Lumens per FT
- **_LMF*** [11] ## Lumens per FT (Limited to 300LMF to 1000LMF in 50LMF increments)

Direct Distribution
- **(blank)** Standard Distribution
- **WW**[5] Wall Wash

Downlight [11]
- **2DL**[6,7] LED Downlight Standard
- **_DL**[6,7] LED downlights per Run (3DL, 4DL, ect.)

Downlight Color Rendering
- **S80CRI** 80 CRI
- **S90CRI** 90 CRI

Downlight Color Temp
- **S27K** 2700K
- **S30K** 3000K
- **S35K** 3500K
- **S40K** 4000K

Minimum Dimming Level
- **NODIM** Non - Dim
- **MIN1** Constant current, dimming to 1%
- **DARK** Constant current, dimming to 0.1%
- **MIN5**[8] Constant current, dimming to 5%
- **MIN10**[18] Constant current, dimming to 10%

Voltage
- **120** 120V
- **277** 277V
- **347**[9,11] 347V

Finish
- **(blank)** White
- **xxx/BLKT** Black, textured
- **xxx/SLVT** Silver, textured
- **xxx/RALTBD** RAL paint finish

xxx = fill in with the appropriate ceiling trim. Only trims are painted

Emergency Options
- **(blank)** No Emergency
- **E10WLCP**[10,19] 4ft Emergency Section with battery pack
- **__E10WLCP**[10,19] Number of 4ft Emergency Section(s) with battery pack
- **_EC**[12] # of Emergency Circuits

Control Input
- **(blank)** Non-dim [13]
- **ZT** 0 10V
- **NLIGHT** nLight enabled
- **NLTAIR2**[20] nLight Air (wireless enabled)
- **ECOD*** [17] Lutron Hi-Lume digital driver
- **ECOD2*** [16,17] Lutron Hi-Lume 2-wire (1% dimming)
- **ECOD5*** Lutron 5-series digital driver (5% dimming)
- **DALI**[22] DALI compatible

Primary Sensor [14]
- **(blank)** No Sensor
- **PDT** Occupancy Sensor- Dual Technology (Passive Infrared & Microphonics)
- **ADC** Daylight dimming sensor
- **API** PIR Occupancy Sensor & Photocell
- **APD** PDT Occupancy Sensor & Photocell

Options
- **CP**[21] Chicago Plenum
- **USPOM** US point of assembly
- **WL**[3,7,15,19] Wet Location Listing
- **DPL** Damp Location Listing
- **PWS** 6' pre-wire, 3/8" diameter, 18 gauge

* Requires longer lead time.

See Notes next page.

Specification Features (continued)

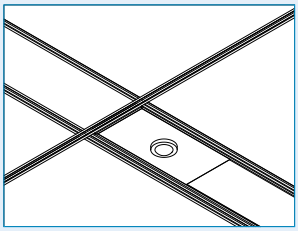
LED Components
Linear: Nichia® - 757 Series LED chips (available in 80 or 90 CRI)

LED Life
Rated 65,000 hours (L80) at 25 °C ambient temperature.

Color Consistency
The Acuity Brands circuit boards for the linear LED components use a precise binning algorithm which creates a consistent color temperature from board to board. Color variation is no greater than a 2.5 Step MacAdam (2.5SDCM) along the black body locus from board to board.

Driver
eldoLED constant current driver options delivers ultra-smooth dimming resolution from 100% to 0.1%, while assuring flicker free, low current inrush, 89% efficiency and low EMI.

Integrated Controls
Optional nLight® embedded controls make luminaire addressable-allowing it to digitally communicate with other nLight enabled controls such as dimmers, switches, occupancy sensors and photocontrols. Simply connect all the nLight enabled control devices using standard CAT5 Cabling. (Input option: NLIGHT)



Occupancy Sensor (PDT) and/or Photocell (ADC)

A+ Capable Luminaire
This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

Notes
1. Supplied with lift and shift lay-in lens.
2. Supplied with snap-in lens.
3. Wet Location Label available with Flush Lens only
4. Not intended for post sheetrock installation.
5. Wall Wash not available with downlights or RLP lens option.
6. See notes on page 3, downlights only available with DARK dimming level.
7. Wet Location label not available with downlights, regressed lens, or with Primary Sensor options, or PSW.
8. ECOD5 must select MIN5.
9. Not available with 2ft fixture sections or with E10WLCP, NLIGHT, sensors, or ECO options. Must select MIN1 option.
10. Remote mounted, not available with CP option.
11. Not available with ECOD, ECOD2, ECOD5.
12. Standard 4' EC section, defaults to end of run. 2ft, 3ft and 5ft powers entire fixture, 6ft powers 3ft EC section.
13. Only available with NODIM option.
14. Sensors not available with WW, NODIM driver, WL or RLP option. Default location for sensor is the left side of the fixture, for runs the first fixture will include the sensor.
15. Cannot be installed in vertical surfaces.
16. Must use 120 volt.
17. Must select MIN1 options, not available with sensors.
18. MIN10 not available with 347, sensors, NLIGHT or NLTAIR2, requires ZT.
19. Battery kit is not wet listed. Can be used with WL unit if installed in a dry location.
20. Must select MIN1 or DARK. Not available with RLP, WW, PDT, ADC or 347, DPL or WL. If with EC, cannot be on individual units, and on runs, the EC cannot be on the same section as NLTAIR2.
21. CP not available with NLTAIR2.
22. DALI is only available with DARK or MIN1. It is not available with sensors or downlights.

Certification
CSA tested to UL 1598 standards. Optional Damp or Wet location listings available, see ordering tree.

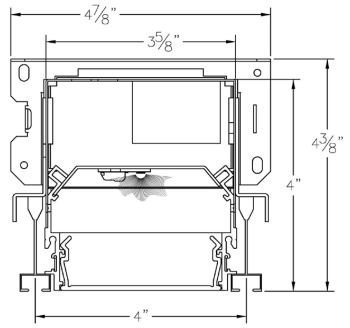
Listings
DesignLights Consortium® (DLC) qualified product. Not all versions of this product may be DLC qualified. Please check the DLC Qualified Products List at www.designlights.org/QPL to confirm which versions are qualified.

Warranty
5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/CustomerResources/Terms_and_conditions.aspx

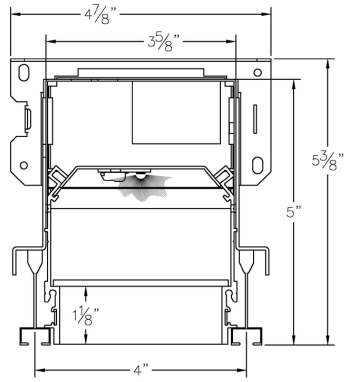
Note: *Actual performance may differ as a result of end-user environment and application.*
All values are design or typical values, measured under laboratory conditions at 25 °C.
Specifications subject to change without notice.

Photometry
For photometric information refer to www.marklighting.com.

Technical Drawing

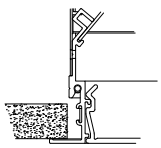


Flush - (FLP)

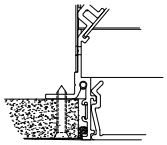


Regressed - (RLP)

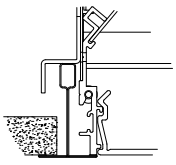
Ceiling Trim



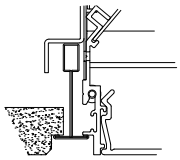
FL
(Flanged sheetrock)



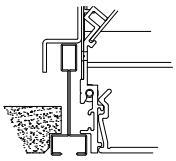
GB
(Flangeless sheetrock)



TG
(15/16" Grid)



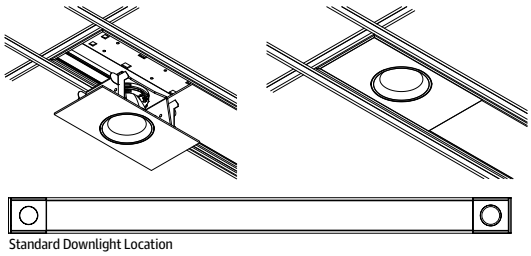
TG
(9/16" Grid)



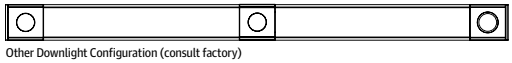
TG
(9/16" Slot Grid)

Downlights

Optional downlights powered by Xicato Spot Modules are available with any linear length and no less than 2' on center spacing. Each downlight module is 6W with 700 lumens delivered (28 degree beam spread). Downlights are supplied with a dedicated feed-point and will be controlled separately.



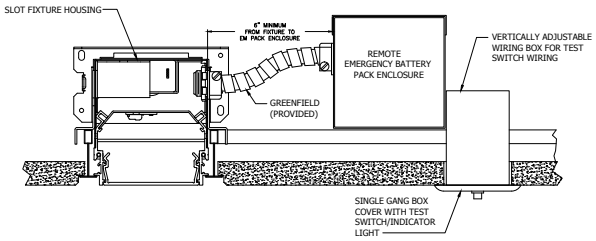
Standard Downlight Location



Other Downlight Configuration (consult factory)

Notes
- 2DL - Downlights are supplied at each end of an individual unit
- __DL - Multiple downlights will be supplied with one at each end and the remainder will be centered over the length of the run.
- Downlights are not adjustable and are provided with solite lens

Remote Emergency Battery Mounting

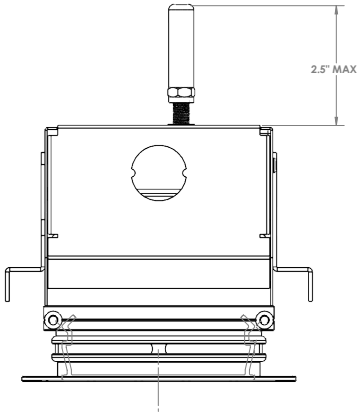


Notes
- Delivers 700 lumens per 4FT length. Default location is the right side of fixture and end of run.
- Provided with 4FT of flexible conduit. Maximum of 25FT remote distance if extended. Extension provided by others.

nLight Air Wireless

nLight Air is now available integrated into the luminaire.

The default location of the antenna will be at the left end of an individual unit. On a run, it will be placed at the beginning or left end of the first section. Please consult factory for other placement options.

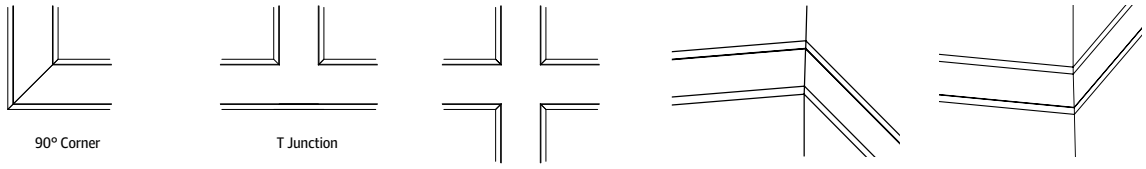


Continuous Runs

Slot 4 LED continuous rows can be configured in 1" increments.

Run Patterns, Corners and Junction

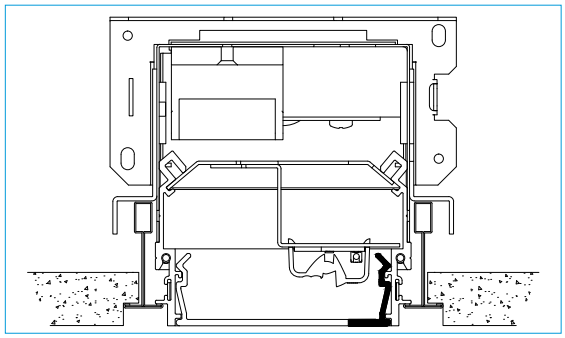
Slot 4 LED patterns be configured in 1' increments with illuminated 90° inside and outside corners, T junctions, and X junctions with standard 2' corner and junction lengths. For custom angles, corner or junction lengths, consult factory.

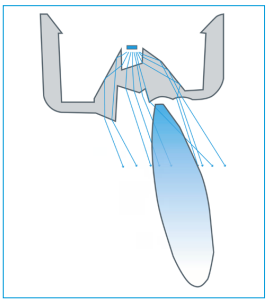


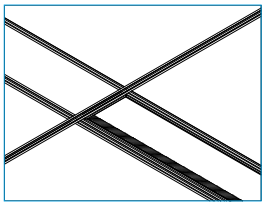
Layout Sketch

Please draw and configure your linear run below.

Optics
Slot LED's patent-pending, precision lumen DIRECTIR optics condition and refract light to deliver accurately controlled, striation-free, and uniform white light. All lumen DIRECTIR optics are injection-molded, optical grade, UV-resistant acrylic with selective finishing/polishing treatment.

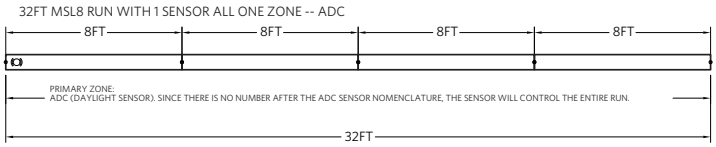






Wall Wash (WW)

INTEGRATED SENSOR LAYOUT



Notes:
- Only one sensor per zone

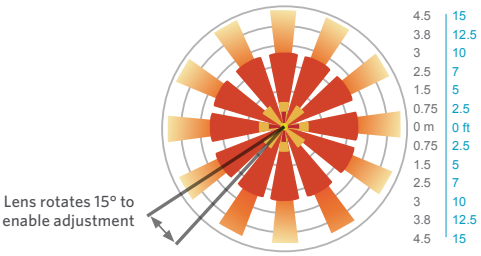
OCCUPANCY DETECTION COVERAGE

At the 7.5 ft (2.9 m) hanging height of a typical pendant mount fixture the sensor provides 10 ft (3.05 m) radial detection of small motion. At a 9 ft (2.74 m) hanging height the radius is 12 ft (3.66 m) for small motion.

Adequate for walking motion detection from mounting heights between 7.5 ft (2.29 m) and 20 ft (6.10 m).

Initial detection will occur earlier when walking across sensor's field of view than when walking directly at sensor.

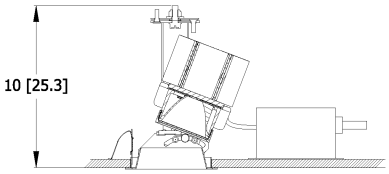
Initial detection of walking motion into long coverage segment will occur at distances of 2x the mounting height up to 15 ft (4.57 m) and 1.75x up to 20 ft (6.10 m). Lens assembly rotates 15° to enable adjustment in order to line up long segments.

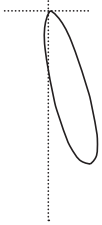


NOT USED

gotham®

Luminaire Type:
Catalog Number (autopopulated):





Gotham Architectural Downlighting
LED Downlights

4" Incito IFB®

Adjustable Open Reflector

Solid-State Lighting
(US and International Patents Pending)

FEATURES

OPTICAL SYSTEM

- Nine optimized distribution patterns allow designers to achieve tailored effects.
- Self-flanged semi-specular or matte-diffuse metal-clad lower reflector utilized in combination with a highly transmissive lens.
- Patented Bounding Ray™ Optical Principle design (U.S. Patent No. 5,800,050) provides source and source image for a smooth and continuous transition from lensed source to the top of the reflector down to the bottom of the reflector.

MECHANICAL SYSTEM

- Light engine and driver are accessible from below ceiling.
- Install from below the ceiling mounting frame and springs.
- Galvanized steel junction box with hinged access covers and spring latch. Capacity: 8 (2 in, 2 out) No. 12 AWG conductors rated for 90°C.
- Accommodates up to 5/8"-thick ceilings.
- Vertical tilt from 0° - 30°, engages with a manual tilt locking screw for added aiming assurance.
- 355 degrees of horizontal rotation.

ELECTRICAL SYSTEM

- Solid-state LED light engine available in 2700 K, 3000 K, 3500 K or 4000 K color temperatures. CRI: 85 typical.
- eldoLED ecoDrive 0-10V driver available with 10% dimming level.
- eldoLED ecoDrive 0-10V driver available with 1% dimming level.
- eldoLED SOLOdrive 0-10V driver available with <1% dimming level.
- eldoLED SOLOdrive DALI driver available with <1% dimming level.
- >70% lumen maintenance at 60,000 hours.

LISTINGS

- CSA certified to meet US and Canadian standards; damp location listed, (Pending).

WARRANTY

- 5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/CustomerResources/Terms_and_conditions.aspx

Note: Actual performance may differ as a result of end-user environment and application. All values are design or typical values, measured under laboratory conditions at 25 °C.

ORDERING INFORMATION

EXAMPLE: ICOI ADJ 30/20 4AR LSS 20D 120 EZB

Series	Color temperature	Nominal lumen values[1]		Aperture/Trim color	Trim Style	Finish
ICOI ADJ	**27/** 2700 K **30/** 3000 K **35/** 3500 K **40/** 4000 K	**05** 500 lumens **07** 750 lumens **10** 1000 lumens **12** 1250 lumens **15** 1500 lumens **20** 2000 lumens	**25** 2500 lumens **30** 3000 lumens **35** 3500 lumens **40** 4000 lumens **45** 4500 lumens	**4AR** Clear **4PR** Pewter **4WTR** Wheat **4GR** Gold **4WR**[2] White **4BR**[2] Black	(blank) Self-flanged	**LSS** Semi-specular **LD** Matte diffuse

Beam	Voltage	Driver	Options
10D 10° beam angle **15D** 15° beam angle **20D** 20° beam angle **25D** 25° beam angle **30D** 30° beam angle **35D** 35° beam angle **40D** 40° beam angle **45D** 45° beam angle **50D** 50° beam angle	**120** **277**	**EZ10** eldoLED 0-10V ECOdrive. Linear dimming to 10% min. **EZ1** eldoLED 0-10V ECOdrive. Linear dimming to 1% min. **EZB** eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%. **EDAB** eldoLED SOLOdrive DALI. Logarithmic dimming to <1%.	**TRW**[3] White painted flange **TRBL**[7] Black painted flange plenum **CRI90** High CRI (90+)

ACCESSORIES order as separate catalog numbers (shipped separately)	
OPTC4[8]	Additional optics for field installation.

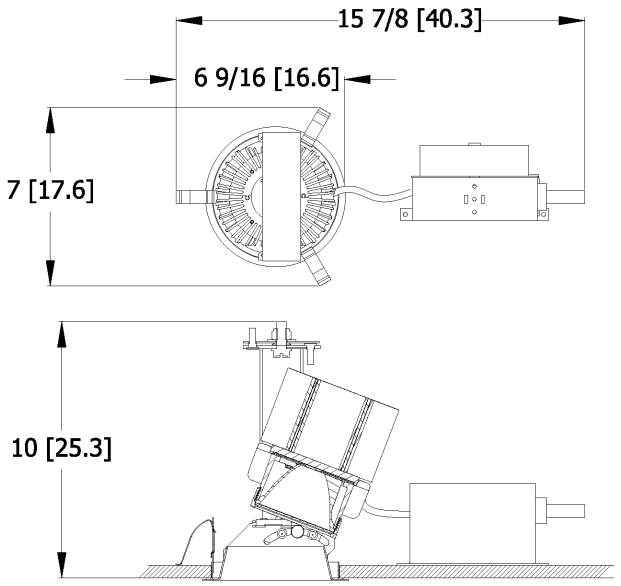
PRELIMINARY

gotham®

DIMENSIONAL DATA

All dimensions are inches (centimeters) unless otherwise noted.

DIMENSIONS FOR 1000lm AND ABOVE



Aperature: 4-5/16 [11]
Ceiling Opening: 5-1/8 [13]
Overlap Trim: 5-11/16 [14.4]

ELECTRICAL

WATTAGE CONSUMPTION MATRIX	
NOMINAL DELIVERED LUMENS	**Wattage**
4500	50 W
4000	43 W
3500	36 W
3000	39 W
2500	33 W
2000	23 W
1500	17 W
1250	12 W
1000	10 W
750	7 W
500	6 W

NOTES

ORDERING NOTES

1. Nominal downlight lumens.
2. Not available with finishes.
3. Not configurable with white reflector.
7. Not configurable with black reflector.
8. Must specify desired optical distribution from available options in "Beam" option column in the ordering tree. i.e. OPTC4 20D.

PRELIMINARY

NOT USED

DELTALIGHT®

Date

Name

Client

Project name

Quote#

Type/Quantity

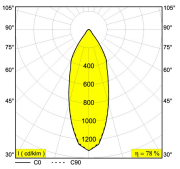
21/02/2020 19:13:14

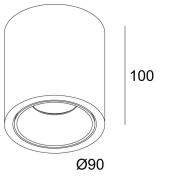
Specification Sheet

BOXY R 93033

251 70 811 932

Weblink





Available colors:	BLACK-BLACK (251 70 811 932 B-B) BLACK-GOLD MATT (251 70 811 932 B-MMAT) WHITE-BLACK (251 70 811 932 W-B) WHITE-WHITE (251 70 811 932 W-W)

NON ADJUSTABLE
INCL.1 x LED 10,4W / CRI>90 / 3000K / 1075lm
INCL.1 x REFLECTOR FL-33°
INCL.LED POWER SUPPLY 500mA-DC
Other CRI or KELVIN on request

LED Technics:	Light source: 1075 lm // 10 W // 110 lm/W Luminaire: 841 lm // 12 W // 70 lm/W
110-240V / 50-60Hz	
Class:	I
Weight: Protection level: Minimum distance:	0.6 KG IP40 n.a.
Options:	COVERSET R 100
Accessories:	BOXY HONEYCOMB BOXY SOFTENING LENS BOXY GLASS SBL

For detailed installation instructions, please consult the manual. 251_70_811_XXX_HAND.pdf

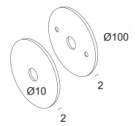
DELTALIGHT®

Specification Sheet

BOXY R 93033
251 70 811 932

Related references
COVERSETS

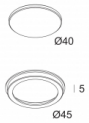
Weblink / Specsheet



COVERSET R 100
204 00 100

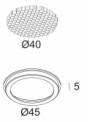
Related references
LIGHT ALTERING DEVICES

Weblink / Specsheet



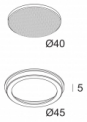
BOXY GLASS SBL
251 70 03 05

Weblink / Specsheet



BOXY HONEYCOMB
251 70 03 01

Weblink / Specsheet



BOXY SOFTENING LENS
251 70 03 04

DELTALIGHT®

Specification Sheet

BOXY R 93033
251 70 811 932

Related project picture of product family:

gotham® | INCITO™

Multiple Layers of Light

Luminaire Type:

Catalog Number:

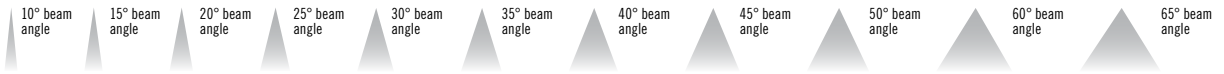
High Center Beam Surface Ceiling Cylinder 4"

OVERVIEW

Feature Set

- Eleven optimized distribution patterns allow designers to achieve tailored objectives
- Bounding Ray™ optical design
- 45° Cutoff to source and source image
- Fully serviceable lensed LED light engine
- 70% lumen maintenance at 60,000 hours
- 2.5 SDCM; 85 CRI typical, 90+ CRI optional
- Fixtures are damp location standard; wet location option (WL), covered ceiling
- 20 standard colors in textured and gloss finish; custom or RAL colors also available
- Field configurable surface junction box conduit covers available
- ENERGY STAR® Certified product

Distribution



Superior Perfomance

Nominal Lumens	500	750	1000	1500	2000	2500	3000	3500	4000	4500	5000
Delivered	703	807	1062	1545	1977	2419	2920	3548	3982	4419	4848
Wattage	6.7	7.5	9.8	15.1	21.5	26.5	34.1	33.8	39.5	46.2	53.2
Efficacy	104	108	108	102	92	91	86	105	101	96	91

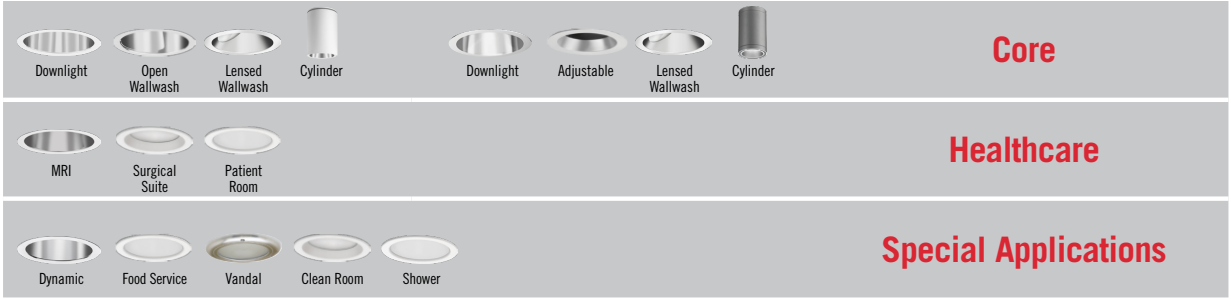
COMPLIMENTARY PRODUCTS

Coordinated Apertures | Multiple Layers of Light

General Illumination Layer | EVO

High Center Beam Layer | Incito

EVO + Incito — Multiple Layers of Light



GOTHAM ARCHITECTURAL DOWNLIGHTING | 1400 Lester Road Conyers, GA 30012 | P 800-705-SERV (7378) | gothamlighting.com

ORDERING INFORMATION

A+ Capable options indicated by this color background.

Luminaire Type:

Catalog Number:

EXAMPLE: ICO4SC 35/15 AR LSS 35D MVOLT EZ1 JBXCC DWHG

Series		Color Temperature		Lumens		Reflector Color		Reflector Finish		Beam		Voltage	
ICO4SC	Incito 4in Surface Ceiling Round Cylinder Open Downlight	27/	2700 K	05	500 lumens	AR	Clear	LSS	Semi-specular	10D[2]	10° beam angle	MVOLT	120V - 277V
		30/	3000 K	07	750 lumens	PR	Pewter	LD	Matte diffuse	15D	15° beam angle	120	120V
		35/	3500 K	10	1000 lumens	WTR	Wheat	LS	Specular	20D	20° beam angle	277	277V
		40/	4000 K	15	1500 lumens	GR	Gold			25D	25° beam angle	347[3]	347V
		50/	5000 K	20	2000 lumens	WR[1]	White painted			30D	30° beam angle		
				25	2500 lumens	BR[1]	Black			35D	35° beam angle		
				30	3000 lumens	BZR[1]	Dark Bronze painted			40D	40° beam angle		
				35	3500 lumens					45D	45° beam angle		
				40	4000 lumens	WRAMF[1]	White Anti-microbial			50D	50° beam angle		
				45	4500 lumens					60D	60° beam angle		
				50	5000 lumens					65D	65° beam angle		

Driver[4]		Mounting		Control Interface[7]	
GZ10	0-10V driver dims to 10%	JBX	Integral driver, Recessed or Surface J-box	(blank)	No controls
GZ1	0-10V driver dims to 1%	JBXCC	Integral driver, Surface J-box with Conduit Covers	NLT	nLight® dimming pack.
EZ10	eldoLED 0-10V ECOdrive. Linear dimming to 10% min.			NLTER[8]	nLight® dimming pack for fixtures on emergency circuit
EZ1	eldoLED 0-10V ECOdrive. Linear dimming to 1% min.			NLTAIR2	nLight® AIR dimming pack.
EZB	eldoLED 0-10V SOLOdrive. Logarithmic dimming to <1%.			NLTAIRER2[8]	nLight® AIR dimming pack for fixtures on emergency circuit
EDAB[6]	eldoLED SOLOdrive DALI. Logarithmic dimming to <1%.				
EDXB[5,6]	eldoLED POWERdrive DMX with RDM (remote device management). Square Law dimming to <1%. Min: 1000LM; Max: 4000LM.				
ECOS2[6]	Lutron® Hi-Lume® 2-wire forward-phase driver. 120V Only. Minimum dimming level 1%. Min: 1000LM; Max: 2000LM.				
ECOD[6]	Lutron® EcoSystem® digital Hi-Lume 1% soft-on, fade to black. Min: 500LM; Max: 750LM.				

Options		Architectural Colors - Powder Paint[11]			
SF	Single fuse. Specify 120V or 277V.	DDB	Gloss Dark Bronze	DDBT	Textured Dark Bronze
90CRI	High CRI (90+)	DBL	Gloss Black	DBLB	Matte Black
N80	nLight Lumen Compensation	DWH	Gloss White	DWHG	Textured White
HAO[9]	HAO High Ambient Option (40°C)	DMB	Gloss Medium Bronze	DBNH	Textured Bronze
WL[10]	Wet Location	DNA	Gloss Natural Aluminum	DNAT	Textured Natural Aluminum
		DSS	Gloss Sandstone	DSST	Textured Sandstone
		DGC	Gloss Charcoal Grey	DSPD	Textured Dark Grey
		DTG	Gloss Tennis Green	DSPE	Textured Green
		DBR	Gloss Bright Red	DSPH	Textured Light Red
		DSB	Gloss Steel Blue	DWHAMF	Gloss White with Anti-microbial finish

ACCESSORIES —order as separate catalog numbers (shipped separately)

OPTC4 XXD	Additional optics for field installation. Replace "XX" with beam angle.
CYLJBOXADPT 4SQ2OCT __	4in Square J-box to 4in Octagonal J-box adaptor. Replace __ with Architectural Color or PRM for primed ready for field painting

ORDERING NOTES

1. Not Available with Finishes.
2. Only available 1500lm and below.
3. Factory supplied step down transformer must be remote mounted. Access required to location of remote mounted device.
4. Refer to Tech 240 for compatible dimmers.
5. Includes terminator resistor.
6. Not Available with Control Interfaces.
7. Field installed. Access required to location of remote mounted device.
8. For use with generator supply EM power. Will require an emergency hot feed and normal hot feed.
9. Only available up to 2500 lumens. Not available with WL or ECOS2.
10. Not available with JBXCC. Max: 2500LM.
11. For details on RAL and Custom colors please see Architectural colors

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SPECIFICATIONS

Optical Assembly

Fully serviceable and upgradeable lensed LED light engine suitable for field maintenance or service from below the ceiling.

Optical design is a Bounding Ray™ design with 45° cutoff to source and source image. Top down flash characteristic for superior glare control.

Electrical

The luminaire shall operate from a 50 or 60 Hz ±3 Hz AC line over a voltage ranging from 120 VAC to 277 VAC. Support 347V via remote-mounted stepdown transformer. The fluctuations of line voltage shall have no visible effect on the luminous output.

The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.

Sound Rated A+. Driver shall be >80% efficient at full load across all input voltages.

Input wires shall be 18AWG, 300V minimum solid copper.

Controls

Luminaire shall be equipped with interface for nLight wired or nLight AIR networks with integral power supply as per specification.

Emergency

Luminaires supplied with a battery pack comply with NFPA 101 (Life Safety code) and deliver constant light output throughout the 90 minutes of code required emergency operation period when there is a normal AC power loss.

Luminaires equipped with a generator transfer device work in conjunction with an auxiliary generator or a central inverter system to power fixtures for safe egress lighting.

Dimming

The luminaire shall be capable of continuous dimming without perceivable stroboscopic flicker as measured by flicker index (ANSI/IES RP-16-10) over a range of 100 – 10%, 100 – 1.0% or 100 – 0.1% of rated lumen output with a smooth shut off function to step to 0%.

eldoLED LED drivers shall conform to IEEE P1789 standards. Alternatively, manufacturers must demonstrate conformance with product literature and testing which demonstrates this performance. Systems that do not meet IEEE P1789 will not be considered.

Driver is inaudible in 24dB environment, and stable when input voltage conditions fluctuate over what is typically experienced in a commercial environment.

Construction

Heaving-gauge aluminum construction.

Extruded body with flangeless reflector allows flow-through passive thermal management.

Surface ceiling mount for direct installation to 4" recessed or surface octagonal or square junction box.

Optional field configurable conduit covers available. Conduit covers match cylinder in finish and diameter.

Recessed gear box available for driver above ceiling, nLight, or battery pack options.

Listings

Fixtures are CSA Certified to meet US and Canadian Standards: All fixtures manufactured in strict accordance with the appropriate and current requirements of the "Standards for Safety" to UL, damp location standard; wet location covered ceiling optional (WL).

Luminaire configurations are Energy Star certified through testing in EPA–recognized laboratories, with the results reviewed by an independent, accredited certification organization. Visit www.energystar.gov for specific configurations listed.

Photometrics

LEDs tested to LM-80 standards. Measured by IESNA Standard LM-79-08 in an accredited lab. Lumen output shall not decrease by more than 30% over the minimum operational life of 60,000 hours.

Color appearance from luminaire to luminaire of the same type and in all configurations, shall be consistent both initially and at 6,000 hours and operate within a tolerance of <2.5 MacAdam ellipse as defined by the center of the quadrangles defined in ANSI C78.377-2015.

Warranty

5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/support/customer-support/terms-and-conditions

Note:

Actual performance may differ as a result of end user environment and application.
All values are design or typical values, measured under laboratory conditions at 25 °C.

A+ Capable Luminaire

This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight® control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

GOTHAM ARCHITECTURAL DOWNLIGHTING | 1400 Lester Road Conyers, GA 30012 | P 800-705-SERV (7378) | gothamlighting.com

ICO - eldoLED Driver Default Dimming Curve			
Nomenclature	Min Dimming	Driver Dim Curve	Control Dim Curve
EZ10	10%	Linear	Linear/Logarithmic
EZ1	1%	Linear	Linear/Logarithmic
EZB	<1%	Logarithmic	Linear
EDAB	<1%	Logarithmic*	Linear
EDXB	<1%	Square	Linear

*Changable thorugh DALI controller

Lumen Output Multiplier		
CRI	CCT	Multplier
80	2700K	0.916
	3000K	0.948
	3500K	1
	4000K	1.032
	5000K	1.1
90	2700K	0.748
	3000K	0.8
	3500K	0.838
	4000K	0.845
	5000K	0.945

Reflector Finish Multiplier	
Reflector Finish	Multiplier
LS - Specular	1
LSS - Semi Specular	0.956
WR - White	0.87
LD - Matte Diffuse	0.85
BR - Black	0.73
BZR - Bronze	0.73

Driver		Control Provided (note: 347V/UVOLT versions provided with 347 option selected)			
Nomenclature	Description	NLT	NLTER	NLTAIR2	NLTAIRER2
GZ10	0-10V driver dims to 10%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V ER G2
GZ1	0-10V driver dims to 1%	nPP16 D EFP	nPP16 D ER EFP	RPP20 D 24V G2	RPP20 D 24V ER G2
EZ10	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2
EZ1	eldoLED 0-10V ECOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2
EZB	eldoLED 0-10V SOLOdrive	nPS 80 EZ	nPS 80 EZ ER	RPP20 D 24V G2	RPP20 D 24V ER G2

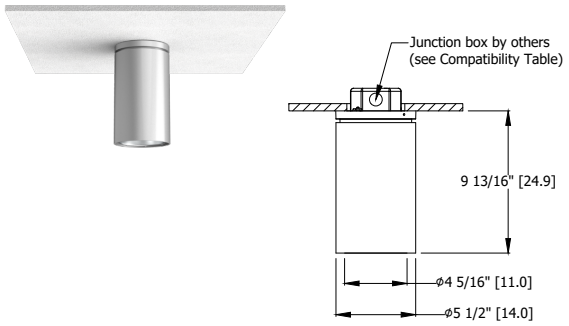
J-box Compatibility Matrix		Cylinder Configurations		
		JBX	JBX w/EDXB Driver	JBXCC
Recommended J-box (by others)	4" Octagonal 4x4x1.5 deep"	✓	✗	✓
	4" Octagonal 4x4x2.125 deep	✓	✓	✗
	4" Square 4x4x1.5 deep	✓ *with adaptor plate accessory	✗	✗

Standard Architectural Color Options for Cylinder Bodies

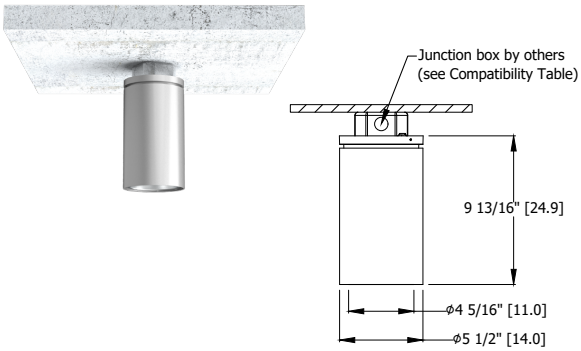
NOTE: These colors were carefully reproduced to give as true a depiction as possible of finished product color. Some colors, however, may vary slightly from actual appearance due to display/printing variations and limitations. Please always contact a Gotham representative for an accurate paint chip sample.

DIMENSIONAL DATA

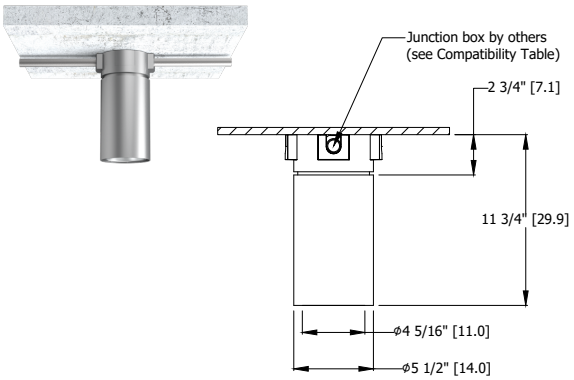
JBX Recessed J-Box



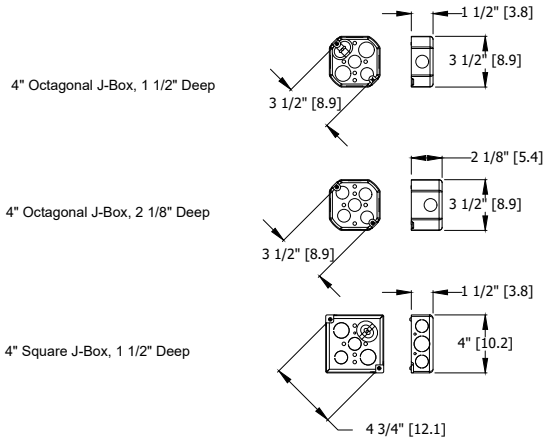
JBX Surface J-Box



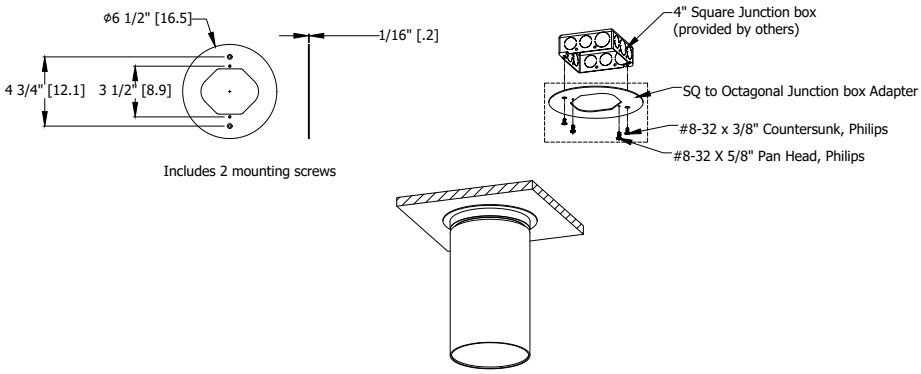
JBXCC Surface J-Box with Conduit Covers



Junction Box Dimensions (by others)



Cylinder Adapter Plate

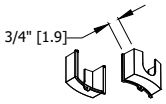


*Dimensions in inches [centimeters]

gotham®

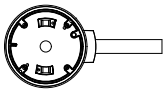
DIMENSIONAL DATA

Conduit Feed Examples and Keys

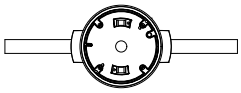


Conduit Key
(4) provided with each,
for use with 1/2" or 3/4" conduit

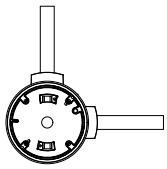
Blank Key
(4) provided with each



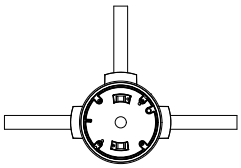
Single Conduit Feed



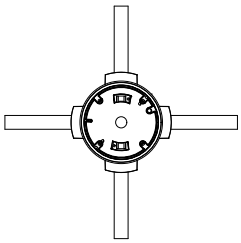
Double 180° conduit



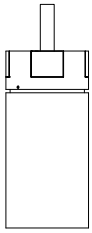
Double 90°conduit



Triple 0°, 90° & 180° conduit

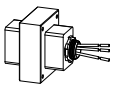


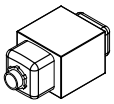
Quad 0°, 90°, 180°, & 270° conduit

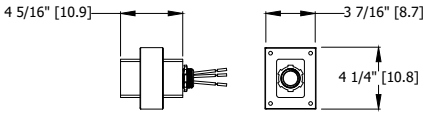


Top conduit feed

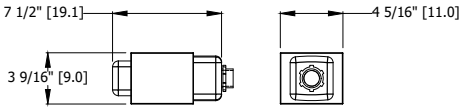
347V Stepdown Transformer







347 Transformer:
Up to 6000LM
Install to accessible
junction box by others



347 Transformer:
8000LM and up
Install to accessible
junction box by others

*Dimensions in inches [centimeters]

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CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

Photometry

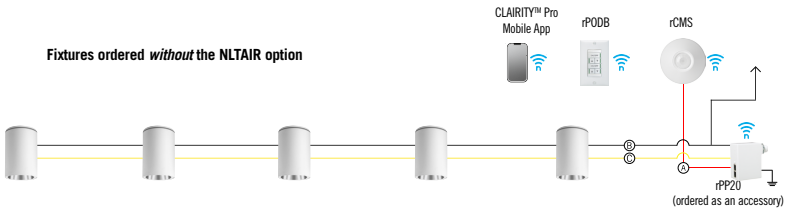
Consult product webpage at WWW.GOTHAMLIGHTING.COM or WWW.ACUITYBRANDS.COM

NLIGHT AIR

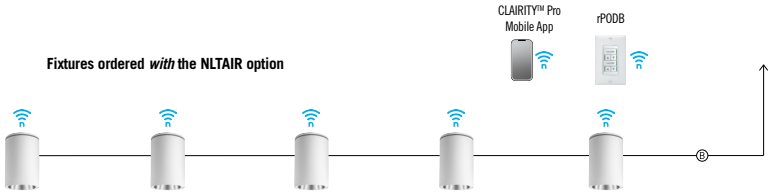
Possibilites for nLight® AIR

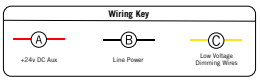
nLight® AIR is the ideal solution for retrofit or new construction spaces where adding communication wiring is cost prohibitive. The integrated nLight AIR rPP20 Power Pack is part of each EVO Luminaire ordered with the NLTAIR option. These individually addressable controls offer the ultimate in flexibility during initial setup and for space repurposing.

Fixtures ordered *without* the NLTAIR option



Fixtures ordered *with* the NLTAIR option





nLight® AIR Control Accessories
Order as separate catalog number. Visit nLight AIR.

Wall Switches	Model Number
On/Off single pole	rPODB (color) G2
On/Off two pole	rPODB 2P (color) G2
On/Off & raise/lower single pole	rPODB DX (color) G2
On/Off & raise/lower two pole	rPODB 2P DX (color) G2

nLight® AIR Control Accessories *(cont.)*

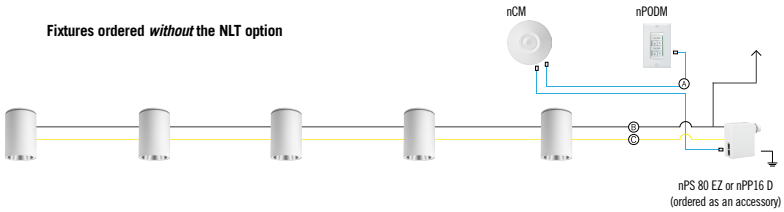
Occupancy Sensors (PIR/dual tech)	Model Number
Small motion 360º, ceiling	rCMS 9 / rCMS PDT 9
Large motion 360º, ceiling	rCMS 10 / rCMS PDT 10

NLIGHT

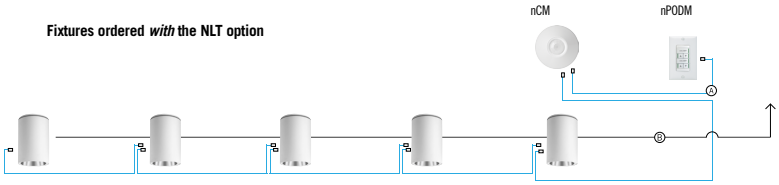
Possibilites for nLight® wired

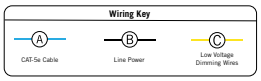
nLight® Wired The nLight® solution is a digital networked lighting control system that provides both energy savings and increased user configurability by cost effectively integrating time-based, daylight-based, sensor-based and manual lighting control schemes.

Fixtures ordered *without* the NLT option



Fixtures ordered *with* the NLT option





nLight® Wired Control Accessories
Order as separate catalog number. Visit nLight.

Wall Switches	Model Number
On/Off single pole	nPODM (XX)
On/Off two pole	nPODM 2P (XX)
On/Off & raise/lower single pole	nPOD DX (XX)
On/Off & raise/lower two pole	nPODM 2P DX (XX)
Graphic touchscreen	nPOD GFX (XX)
Photocell Controls	
Dimming	nCM ADCX

nLight® Wired Control Accessories *(cont.)*

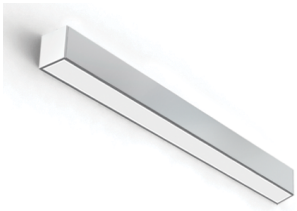
Occupancy Sensors (PIR/dual tech)	Model Number
Small motion 360º, ceiling	nCM 9 / nCM PDT 9
Large motion 360º, ceiling	nCM 10 / nCM PDT 10
Wide View	nWV 16 / nWV PDT 16
Wall switch with raise/lower	nWSX LV DX / nWSX PDT LV DX
Cat-5 Cables (plenum rated)	
10', CAT5	CAT5 10FT J1
15', CAT5	CAT5 15FT J1

GOTHAM ARCHITECTURAL DOWNLIGHTING | 1400 Lester Road Conyers, GA 30012 | P 800-705-SERV (7378) | gothamlighting.com

gotham®

MARK
ARCHITECTURAL
LIGHTING™

Slot 2 LED
Direct Wall



The Slot LED family of luminaires offers an unparalleled package of performance and features for your next lighting project. Precision lumen DIRECTIR optics deliver optimized light where needed for ceilings and walls. With other key features such as simplified installation, seamless controls integration and superior color constancy, the Slot LED family from Mark Lighting offers exceptional quality and design flexibility.

Type:

Project:

Catalog Number:
DO NOT TYPE HERE. Autopopulated field.

Specification Features

Housing
Nominal 2.5" x 4.375" extruded aluminum housing

Finish
White, Black or Silver powdercoat

Reflector
Formed steel with high reflectance white

Distribution/Shielding
Extruded 90% transmissive acrylic lens with a textured surface providing diffuse illumination and a uniform appearance for direct lambertian distribution (No Optics). Wall Graze (WG) distribution options incorporate co-extruded lenses. Shielding is available as an external blade louver for WG option, or an internal blade louver in lieu of lambertian distribution diffuser. Clear Acrylic dustcover (DC) is available for the indirect distribution only.

LED Components
Linear: Nichia®- 757 series LED chips (>80 CRI)

Electrical
Long-life LEDs, coupled with high-efficiency drivers, provide superior quantity and quality of illumination for extended service life. 80% LED lumen maintenance at 60,000 hours (L80/60,000).

Color Consistency
The Acuity Brands circuit boards for the linear LED components use a precise binning algorithm which creates a consistent color temperature from board to board. The color a variation of no greater than a 2.5 Step MacAdam (2.5SDCM) along the black body locus from board to board.

Driver
eldoLED® driver provides natural dimming with smooth, continuous and flicker-free deep dimming. Supports operation between 120VAC and 277 VAC, with low inrush current (NEMA 410) and THD < 20%. Meets FCC Title 47 C.F.R. 15 Class A or Class B requirements. Lutron high performance driver options also available.

Certification
CSA tested to UL 1598 standards, assembled in the USA. Damp location listed.

Listings
DesignLights Consortium® (DLC) qualified product. Not all versions of this product may be DLC qualified. Please check the DLC Qualified Products List at www.designlights.org/QPL to confirm which versions are qualified.

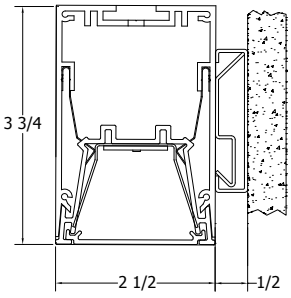
Warranty
5-year limited warranty. Complete warranty terms located at:
www.acuitybrands.com/CustomerResources/Terms_and_conditions.aspx

Note: *Actual performance may differ as a result of end-user environment and application.*

All values are design or typical values, measured under laboratory conditions at 25 °C.

Specifications subject to change without notice.

Technical Drawing



Direct Wall

Fixture Performance

4FT INDIVIDUAL (35K)	DIRECT			
Lumens Output	**400LMF**	**600LMF**	**800LMF**	**1000LMF**
Delivered Lumens	1713	2608	3440	4048
Input Watts	14.8	22.6	30.5	37.1
Lumen/Watt	116	115	112	113

** Consult factory for customized lumen output and wattage between 350LMF and 1050 LMF*

A+ Capable Luminaire
This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

A+ Capable options indicated by this color background.

Ordering

Example: S2LWD 32FT MSL8 80CRI 30K 600LMF MIN1 120 WHT ZT

Series

S2LWD	Slot 2 Wall - Direct

Plan

LCB	Linear center balanced
LLP	Linear longest possible

Total Run Length

_FT	Specify continuous run length (in whole feet, 2' minimum)

Unit length may affect available options.
2' & 3' only available as individual units

For runs longer than 8FT: ALWAYS order the run by the TOTAL RUN LENGTH. Ordering the sections individually will not provide the correct joining hardware to allow connection in the field.

Max Section Length

MSL4	4'
MSL5	5'
MSL6	6'
MSL7	7'
MSL8	8'

Direct Light Source Color Rendering

80CRI	80 CRI
90CRI	90 CRI

Direct LED Color Temp

27K	2700K
30K	3000K
35K	3500K
40K	4000K
50K	5000K

Direct LED Light Output

400LMF	400 lumens per FT
600LMF	600 lumens per FT
800LMF	800 lumens per FT
1000LMF	1000 lumens per FT
_LMF[1]	# lumens per FT

Direct Distribution (Optics)

(blank)	Standard lambertian distribution
WG	Wall graze distribution

WG not available with EGLD, LVRR or LVRRA.

Minimum Dimming Level

NODIM[2]	Non-dimming
MIN1	Constant current, dimming to 1%
DARK	Constant current, dimming to 0.1%

Optional Shielding

(blank)	Standard Shielding only
LVRD[3]	Dropped louver
LVRR[5]	Regressed louver painted to match fixture finish
LVRRA[5]	Regressed louver, aluminum finish
EGLD[3,4]	Edge View direct lens

Voltage

MVOLT	Multi-volt, 120-277V
120	120V
277	277V
347[6]	347V

Finish

WHT	White (gloss)
BLK	Black (gloss)
SLV	Silver (gloss)
WHTT	White (textured)
BLKT	Black (textured)
SLVT	Silver (textured)
RALTBD	RAL paint finishes

Emergency Options

E10WLCP[7]	4' emergency section w/battery pack, 1250 lumens
_E10WLCP[7]	4' emergency section w/battery pack, 1250 lumens
_EC[8]	# of emergency circuits
BGTD[9]	Generator transfer device

Not available with 347V.

Control Input

(blank)	Non-dimming, line voltage
ZT	0-10V control
NLIGHT[10]	nLight enabled
DALI[11]	DALI compatible
DMX[11,12]	DMX compatible
ECOD[12,13]	Lutron Hi-Lume digital driver
ECOD2[12,13,14]	Lutron Hi-Lume 2-wire (1% dimming)
ECOD5[12,13]	Lutron 5-series digital driver (5% dimming)

Sensor

(blank)	Select if single zone/no zone without sensor
NS	Select if multi-zone fixture with no sensor in main zone
PDT_[15]	Occupancy Sensor-Dual Technology (Passive Infrared & Microphonics)
ADC_[15]	Photocell-Daylight Dimming Sensor
API_[15]	PIR Occupancy Sensor & Photocell
APD_[15]	PDT Occupancy Sensor & Photocell

Not available on 2' or 3' units.
Not available with 347V & nLight. (Use ZT Control Inputs where applicable.)

Secondary Sensor

(blank)	No additional zones/sensors
SNS	Select if multi-zone fixture with no sensor in secondary zone
SPDT_[15]	Occupancy sensor - dual technology (passive infrared & microphonics)
SADC_[15]	Photocell-daylight dimming sensor
SAPI_[15]	PIR occupancy sensor & photocell
SAPD_[15]	PDT occupancy sensor & photocell

Not available on 2' or 3' units.
Not available with 347V & nLight. (Use ZT Control Inputs where applicable.)

Tertiary Sensor

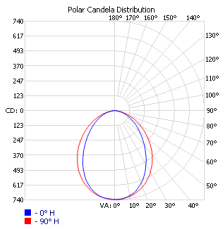
(blank)	No additional zones/sensors
TNS	Select if multi-zone fixture with no sensor in tertiary zone

Options

GLR[12]	Fast-blow fuse
GMF[12]	Slow-blow fuse
DPL	Damp location listing
USPOM	US point of assembly

Notes:
1. Limited to 400LMF to 1000LMF in 50LMF increments. Not available with ECOD, ECOD2, ECOD5 or DMX control input.
2. Not available with Control Input.
3. Not available with Sensor Options.
4. Not available with E10WLCP or BGTD
5. Not available with sensors on 2', 3' & 4' units.
6. Not available with ZT & sensors, with emergency options, with NLIGHT in 5' units, with NLIGHT & downlights.
7. Not available with 2' or 3' units. Not available with DMX control option. One battery pack per unit. Only available on 8' unit with ECOD, ECOD2, ECOD5. If with ZT & API or APD, only available in 7' & 8' units.
8. Powers entire direct unit. Not available with DMX.
9. Must select 120 or 277 volt. Remote mounted. Not available with sensor and BGTD in same unit. Not available with DMX.
10. Comes with white CAT5 cord in addition to the standard power cord. Will require remote mounted nIO on 2' unit. One nlight device per zone or sensor, for multiple zones consult factory.
11. Must select DARK Dim Level.
12. Not available with 347V.
13. Must select MIN1 Dim Level. Not available on 2', 3' or 5' units.
14. 120V only.
15. Requires ZT or NLIGHT Control Input.

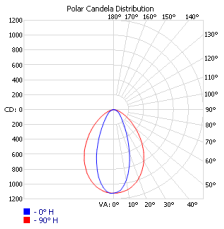
PHOTOMETRICS



Test Report: ISF 37569P0
IES LM 79-08
S2LWD 4FT 80CRI 30K 400LMF
Lumens: 1646
Wattage: 14.75
Efficacy: 111.5

Zonal Lumen Summary		
Zone	Lumens	% Luminaire
0-30	545.6	33.10%
0-40	855.9	52%
0-60	1374.8	83.50%
60-90	270.8	16.50%
70-100	110.5	6.70%
90-120	0.3	0%
0-90	1645.7	100%
90-180	0.4	0%
0-180	1646	100%

Angle	Candlepower Distribution Plane								
	0	22.5	45	67.5	90	112.5	135	157.5	180
0	737	737	737	737	737	737	737	737	737
5	735	732	731	733	732	738	734	735	732
10	713	714	717	720	721	724	721	718	717
15	685	685	689	697	700	706	698	692	688
20	639	642	655	668	671	672	666	652	643
25	582	591	609	625	632	634	618	597	589
30	516	530	554	581	590	585	566	535	526
35	450	463	498	529	539	533	502	471	453
40	385	397	431	469	483	474	437	400	387
45	323	334	370	408	421	414	373	338	325
50	267	280	310	348	362	352	313	281	267
55	219	230	256	288	301	292	255	228	219
60	173	182	204	233	243	237	204	183	175
65	135	142	160	181	191	183	161	143	138
70	100	106	119	132	139	134	118	108	101
75	69	72	79	89	93	91	81	73	71
80	42	43	47	51	53	52	48	45	44
85	19	19	19	19	19	20	20	20	19
90	3	3	2	1	0	2	3	3	3



Test Report: ISF 37776P0
IES LM 79-08
S2LWD 4FT 80CRI 30K 400LMF WG
Lumens: 1420
Wattage: 14.51
Efficacy: 97.8

Zonal Lumen Summary		
Zone	Lumens	% Luminaire
0-30	666.3	46.90%
0-40	934.7	65.80%
0-60	1276.8	89.90%
60-90	140.4	9.90%
70-100	55.4	3.90%
90-120	1.2	0.10%
0-90	1417.1	99.80%
90-180	2.9	0.20%
0-180	1420	100%

Angle	Candlepower Distribution Plane								
	0	22.5	45	67.5	90	112.5	135	157.5	180
0	1121	1121	1121	1121	1121	1121	1121	1121	1121
5	1085	1087	1099	1114	1114	1120	1105	1103	1101
10	965	990	1028	1075	1092	1086	1046	1011	999
15	799	833	918	1007	1044	1019	945	874	848
20	617	663	776	919	981	931	808	705	671
25	450	499	638	818	899	824	671	539	497
30	316	362	500	701	805	716	533	395	356
35	228	264	376	585	700	601	404	287	254
40	172	194	284	474	588	483	304	210	185
45	135	150	215	373	475	382	225	157	142
50	107	117	163	284	372	294	170	122	112
55	88	94	124	214	284	217	128	97	90
60	72	76	95	158	205	160	96	76	72
65	56	59	72	111	146	114	73	60	57
70	43	45	52	77	99	77	52	44	43
75	30	32	36	50	61	49	36	31	30
80	19	20	22	27	33	28	22	20	19
85	9	10	10	12	14	12	10	9	9
90	1	1	2	2	1	1	1	1	1

Shielding

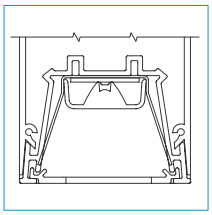

Co-Extruded WG

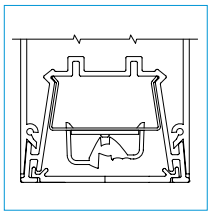

Co-Extruded WW

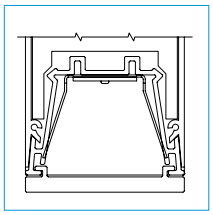

Edge View Lens

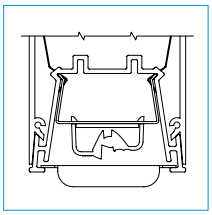

External Louver

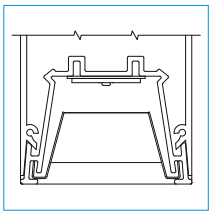

Regressed Louver


Co-Extruded WG (Standard)


Co-Extruded WW (Standard)


Edge View Lens (Optional)


External Louver WW (Painted to Match Housing)


Regressed Louver (Natural Aluminum or Painted to Match Housing)

LINEAR PLAN:

Mark Lighting offers the ability to provide a continuous run plan to suit your requirements by optionally offering three different methods of configuration.

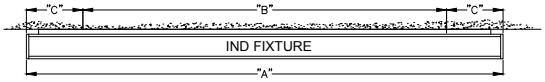
LLP- Linear Longest Possible
In this configuration, the longest length available is optimized, resulting in the fewest segments and mounting locations. Caution, should be used where balanced appearance is a concern. Example: 20 FT run would have 2, 8 FT segment and 1, 4 FT segment at the end of the run.

LLP	8 FT	8 FT	4FT

LCB- Linear Center Balanced:
This configuration incorporates the longest center segment(s) along with any additional lengths required to fill the run length, added to the run ends. Example: 16 FT run would have 2, 4 FT segments (one at each end) and 1, 8 FT segment in the center.

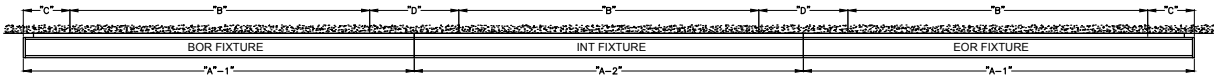
LCB	4 FT	8 FT	4FT

Individual Fixture Configurations



INDIVIDUAL UNITS (MOUNTING)			
LENGTH	"A" O.A.L.	"B" FEED POINTS	"C" FROM END
2FT	2'- 5/8"	1'-1"	5 13/16"
3FT	3'- 5/8"	2'-1"	5 13/16"
4FT	4'- 5/8"	3'-1"	5 13/16"
5FT	5'- 5/8"	4'-1"	5 13/16"
6FT	6'- 5/8"	5'-1"	5 13/16"
7FT	7'- 5/8"	6'-1"	5 13/16"
8FT	8'- 5/8"	7'-1"	5 13/16"

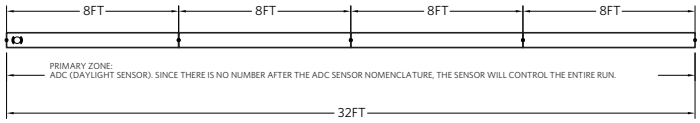
Run Configurations



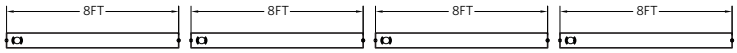
RUN LAYOUT (MOUNTING)					
LENGTH	"A-1" O.A.L.	"A-2" O.A.L.	"B" FEED POINT	"C" FROM END	"D" FEED POINT
4FT	4'- 5/16"	4'-0"	3'-1"	5 13/16"	11"
5FT	5'- 5/16"	5'-0"	4'-1"	5 13/16"	11"
6FT	6'- 5/16"	6'-0"	5'-1"	5 13/16"	11"
7FT	7'- 5/16"	7'-0"	6'-1"	5 13/16"	11"
8FT	8'- 5/16"	8'-0"	7'-1"	5 13/16"	11"

TOTAL RUN LENGTH

This system is not modular. Runs longer that 8FT will be automatically configured with Starter, Middle and Ender sections, based on how you specify the TOTAL RUN LENGTH and MAXIMUM SECTION LENGTH parameters in the ordering information. Always order the total run length, not the individual sections



Example: This run must be ordered as 1pc "S2LWD LLP 32FT MSL8..."



Example: If you order as 4pcs "S2LWD LLP 8FT MSL8... you will receive these INDIVIDUAL sections that cannot be joined together

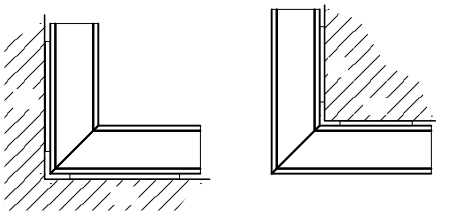
MAXIMUM SECTION LENGTH

The run will be broken out using as many sections at the chosen MSL length as possible. Shorter sections will then complete the desired run length.

Examples:
S2LWD LLP 21FT MSL5... = 5FT / 4FT / 4FT / 4FT / 4FT
S2LWD LLP 21FT MSL6... = 6FT / 6FT / 5FT / 4FT
S2LWD LLP 21FT MSL7... = 7FT / 7FT / 7FT
S2LWD LLP 21FT MSL8... = 8FT / 8FT / 5FT

Run Patterns, Corners and Junction

Slot 2 LED patterns be configured in 1' increments with illuminated 90° inside or outside corners, with standard 2' corner junction lengths. For custom angles, corner or junction lengths, consult factory.
See separate patterns spec sheet for details.

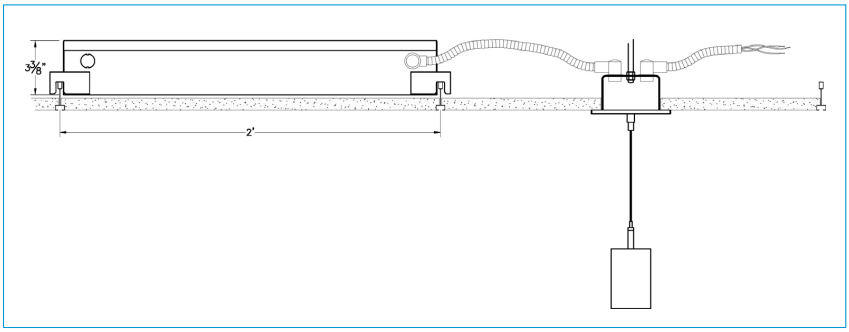


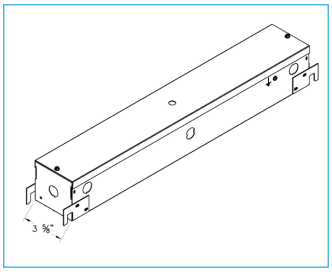
90° Corner

Remote BGTD Mounting Option

Recessed in sheetrock ceiling; rod mounted to structure. Consult factory for other ceiling types or canopy options.

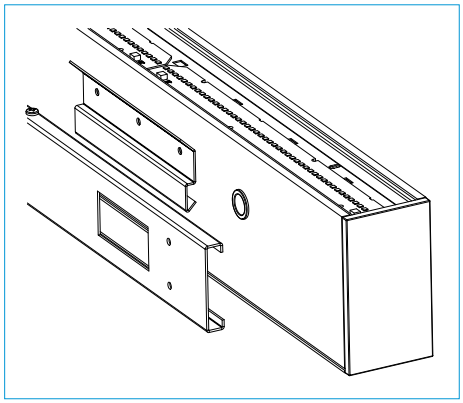
6 foot flexible conduit included, BGTD option should be mounted within 6 feet of junction box above fixture.





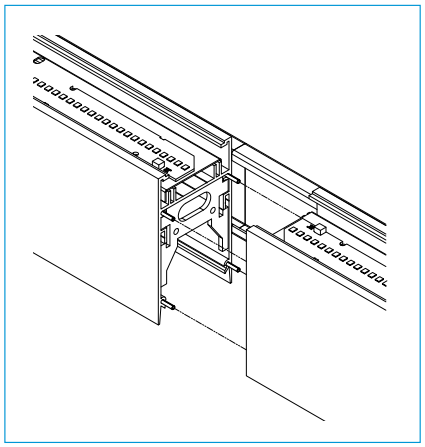
Accessible Ceiling

Mountings

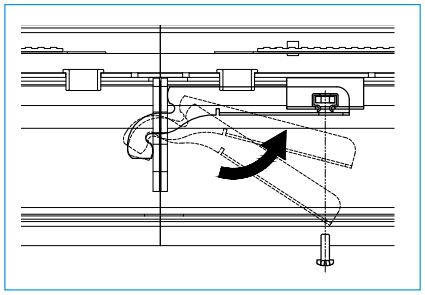


Joiners

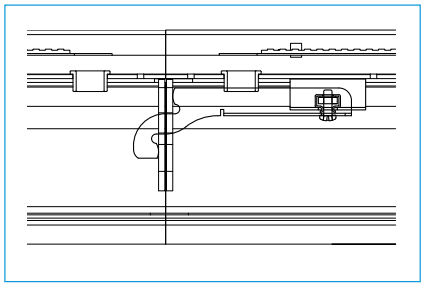
AEL Precision Row-Mount 3-step fixture-to-fixture connection method



Step 1: Align



Step 2: Engage



Step 3: Lock

Continuous Runs

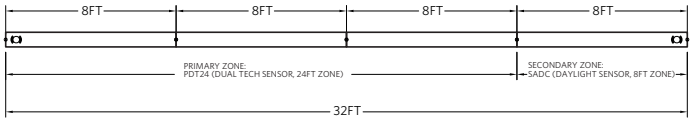
Slot 2 LED continuous rows can be configured in 1' increments and featuring the AEL precision joiner to create a hairline seam between luminaires, providing a monolithic visual aesthetic. For custom run lengths less than a 1' increment, consult factory.

INTEGRATED SENSOR LAYOUT

For runs longer than 8FT:
ALWAYS order the run by the TOTAL RUN LENGTH. Ordering the sections individually will not provide the correct joining hardware to allow connection in the field.

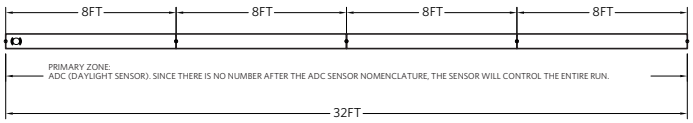
CORRECT:

32FT MSL8 RUN WITH 2 SENSORS WITH PRIMARY ZONE 24FT AND SECONDARY ZONE 8FT -- PDT24 SADC8



Total Run Length to Order

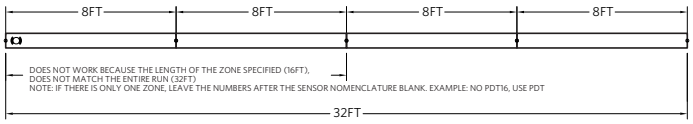
32FT MSL8 RUN WITH 1 SENSOR ALL ONE ZONE -- ADC



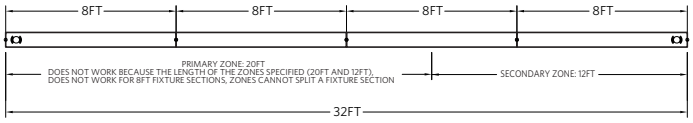
Total Run Length to Order

INCORRECT:

32FT MSL8 RUN WITH 1 SENSOR ALL ONE ZONE -- PDT16



32FT MSL8 RUN WITH 2 SENSORS WITH PRIMARY ZONE 20FT AND SECONDARY ZONE 12FT -- PDT20 SADC12



Notes:
- Only one sensor per zone
- At the most, the entire run can only have 2 sensors (thus 2 sensors zones at the most)
- Sensor zone can not split fixture sections
- No overlapping zones

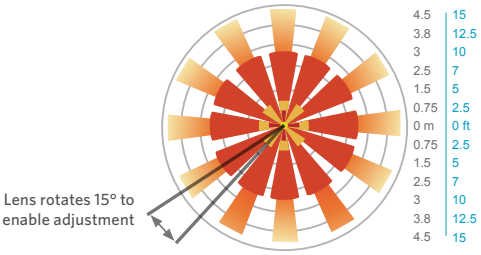
OCCUPANCY DETECTION COVERAGE

At the 7.5 ft (2.9 m) hanging height of a typical pendant mount fixture the sensor provides 10 ft (3.05 m) radial detection of small motion. At a 9 ft (2.74 m) hanging height the radius is 12 ft (3.66 m) for small motion.

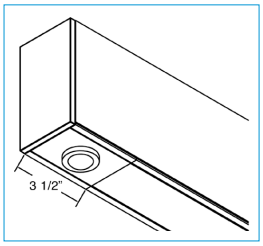
Adequate for walking motion detection from mounting heights between 7.5 ft (2.29 m) and 20 ft (6.10 m).

Initial detection will occur earlier when walking across sensor's field of view than when walking directly at sensor.

Initial detection of walking motion into long coverage segment will occur at distances of 2x the mounting height up to 15 ft (4.57 m) and 1.75x up to 20 ft (6.10 m). Lens assembly rotates 15° to enable adjustment in order to line up long segments.



Integrated Controls
Optional nLight® integrated controls make Slot LED luminaires addressable- allowing them to digitally communicate with other nLight enabled controls such as dimmers, switches, occupancy sensors and photocontrols. Simply connect all the nLight enabled control devices using standard CAT5 Cabling.



Occupancy Sensor and/or Photocell

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

Intelligent Luminaire Technology Guide

Choose nomenclature from these columns

Driver Configurations

Minimum Dimming Level		Control Input		Driver	Dimming Range	Notes
NODIM	+	(blank)	=	0 10V Generic Driver	-	Includes no 0 10V leads from the driver.
MIN10	+	ZT	=	0 10V Generic Driver	100 to 10%	Linear dimming
MIN1	+	ZT	=	0 10V eldoLED ECOdrive	100 to 1%	Formerly (EZ1) nomenclature. Linear dimming
MIN1	+	NLIGHT	=	0 10V eldoLED ECOdrive	100 to 1%	Logarithmic dimming
MIN1	+	ECOD2	=	Lutron forward phase control	100 to 1%	LUTRON Hi-lume 1% 2-wire (model LTEA4U1U)
MIN1	+	ECOD5	=	Lutron Ecosystem	100 to 5%	LUTRON 5 Seires EcoSystem LED Driver (model LDE5)
MIN1		ECOD		Lutron Ecosystem	100 to 1%	LUTRON Hi-lume 1% EcoSystem LED Driver with Soft-on, Fade-to-Black (model LDE1)
DARK		ZT		0 10V eldoLED SOLOdrive	100 to 0.1%	Formerly (EZB) nomenclature. Linear dimming
DARK		NLIGHT		0 10V eldoLED SOLOdrive	100 to 0.1%	Logarithmic dimming
DARK		DALI		DALI compatible eldoLED SOLOdrive	100 to 0.1%	"Compatible with DALI. Formerly (EDB & EDAB) nomenclature." Logarithmic dimming
DARK		DMX		DMX compatible eldoLED POWERdrive	100 to 0.1%	"Compatible with DMX / Remote Device Management. Formerly (EXB & EDXB) nomenclature." Linear dimming

Choose nomenclature from these columns

Control / Sensor Configurations

Control Input		Sensor		Sensor	Notes
ZT	+	API	=	MSD 7 ADCX	Individual fixture control only. PIR integral occupancy sensor with automatic dimming control photocell. (Old nomenclature: ZT + PIR + ADC)
ZT	+	APD	=	MSD PDT 7 ADCX	Individual fixture control only. PDT integral occupancy sensor with automatic dimming control photocell. (Old nomenclature: ZT + PDT + ADC)
NLIGHT	+	(blank)	=	nIO EZ PH	nLight enabled only. No onboard sensor.
NLIGHT		EMG	=	nIO EZ PH ER	Emergency nLight enabled only. No onboard sensor.
NLIGHT	+	API	=	nIO EZ PH + nES 7 ADCX	nLight nES 7 ADCX PIR integral occupancy sensor with automatic dimming photocell. (Old nomenclature: NLIGHT + PIR + ADC)
NLIGHT	+	PDT	=	nIO EZ PH + nES PDT 7	nLight nES PDT 7 dual technology integral occupancy sensor. (Old nomenclature: NLIGHT + PDT)
NLIGHT	+	APD	=	nIO EZ PH + nES PDT 7 ADCX	nLight nES PDT 7 dual technology integral occupancy sensor with automatic dimming photocell. (Old nomenclature: NLIGHT + PDT + ADC)
NLTAIR2		(blank)		RIO EZDL 90D G2	https://www.acuitybrands.com/products/detail/778845/nLight/rIO/Fixture-embedded-nLight-AIR-network-interface
NLTAIR2		API		RES7 G2	https://www.acuitybrands.com/products/detail/593899/nLight/RES7 Sensor/nLight-AIR Fixture-Integrated-Wireless-Sensor
NLTAIR2		APD		RES7 PDT G2	https://www.acuitybrands.com/products/detail/593899/nLight/RES7 Sensor/nLight-AIR Fixture-Integrated-Wireless-Sensor

NOT USED

BeveLED Mini® Complete - B3RD
3" Round Downlight

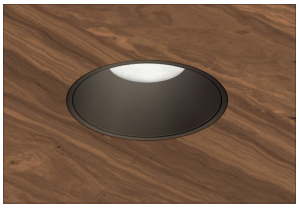
USAI Lighting

Universal and Field Convertible - Trim | Trimless | Millwork

Trimmed - B3RDF

Trimless - B3RDL

Millwork - B3RDM



Trimless Acoustical Tile - B3RDP

usailighting.com/beveledmini

To specify Trimless Acoustical Lighting visit usailighting.com/B3RDP

Introducing new and improved BeveLED Mini, the smallest member of our iconic BeveLED family. BeveLED Mini has been infused with upgraded performance for superior light in every application. Now available with the following features, by popular demand:

FEATURES

- Upgraded performance and more LED color options than ever before!
- Field Flexibility - it's now easy to change trim in the field between trimmed, trimless and millwork
- Dry/damp/wet location rated for bathrooms and showers, including trimless and millwork
- More dimming options and all color technologies available
- Clear overspray protector for installation convenience
- Full family platform
- Iconic beveled look

DOWNLIGHT PERFORMANCE DATA

LED COLOR CHOICES

DELIVERED* PERFORMANCE:	Classic White			Warm Glow Dimming		Color Select	
	9W	15W	20W	15W	20W	12W	18W
Source Lumens:	1175	1825	2475	1350	1800	925	1200
Lumens Per Watt:	102	102	97	68	66	65	57
Delivered Lumens:	925	1425	1950	1025	1375	775	1050

*Based on 3000K. Performance varies for each specific beamspread and color temperature. See IES files for exact values at usailighting.com.

CORRELATED COLOR TEMPERATURE MULTIPLIER	Classic White											
	2700K			3000K			3500K			4000K		
Color Rendering Index:	80+	90+	95+	80+	90+	95+	80+	90+	95+	80+	90+	95+
Multiplier for Lumen	0.96	0.81	0.70	1.00	0.86	0.74	1.03	0.88	0.79	1.06	0.81	0.81

	Warm Glow Dimming					Color Select						
	2700K		3000K		3500K	2200K	2700K	3000K	3500K	4000K	5000K	6000K
Color Rendering Index:	80+	90+	80+	90+	80+	80+	80+	80+	80+	80+	80+	80+
Multiplier for Lumen	1.00	0.78	1.00	0.83	1.05	0.92	0.97	1.00	1.03	1.05	1.10	1.13

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showroom@usailighting.com

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New Windsor, NY 12553
T: 845-565-8500 F: 845-561-1130
info@usailighting.com

BeveLED Mini® Complete - B3RD
3" Round Downlight with Integral Driver Housings

USAI Lighting

Specify fixture part number. (All boxes must be filled in to correctly order)

B3RD__

BeveLED Trim Style

F
Trimmed with Flange (use with all materials)

L
Trimless Spackle-in (use with sheetrock and plaster only)

M
Millwork Knife-Edge (use with wood and stone)

Wattage Options

Classic White Light

09X3
9W LED

15X3
15W LED

20X3
20W LED

Warm Glow Dimming

15WG2
15W LED

20WG2
20W LED

Color Select Tunable White

12CS1
12W LED

18CS1
18W LED (5)

LED Color Options

Classic White Light

27KS
2700K, 80+ CRI

27KH
2700K, 90+ CRI

27KU
2700K, 95+ CRI

30KS
3000K, 80+ CRI

30KH
3000K, 90+ CRI

30KU
3000K, 95+ CRI

35KS
3500K, 80+ CRI

35KH
3500K, 90+ CRI

35KU
3500K, 95+ CRI

40KS
4000K, 80+ CRI

40KH
4000K, 90+ CRI

40KU
4000K, 95+ CRI

Warm Glow Dimming

2722KS
2700K-2200K, 80+ CRI

2722KH
2700K-2200K, 90+ CRI

3022KS
3000K-2200K, 80+ CRI

3022KH
3000K-2200K, 90+ CRI

3522KS
3500K-2200K, 80+ CRI

Color Select Tunable White

6022KS
6000K-2200K, Tunable White Light 80+ CRI

Beam Options

Classic White Light

40
40° beam

55
55° beam

65
65° beam

Warm Glow Dimming

45
45° beam

55
55° beam

65
65° beam

Color Select Tunable White

45
45° beam

55
55° beam

65
65° beam

Lens Options

S
Solite (provided standard)

SF
Solite Frosted

BF
Borosilicate Frosted

Bevel Trim Finish Options

WH
White

SC
Conduit Silver

GR
Grey

BL
Black

BZ
Bronze

PR
Primer Finish

AC
Clear Matte Anodized

AB
Piano Gloss Black

RAL
Custom Color Specify RAL #

*Flange/ Millwork Collar Finish

WH
White

SC
Conduit Silver

GR
Grey

BL
Black

BZ
Bronze

PR
Primer Finish

AC
Clear Matte Anodized

WH
White

BL
Black

GR
Grey

BZ
Bronze

AB
Piano Gloss Black

WH
White

GR
Grey

BL
Black

BZ
Bronze

RAL
Custom Color Specify RAL #

*Leave blank for Trimless

Housing Options

FT
Flat Housing New Construction (1, 2)

FTIC
Flat Housing IC-Rated (up to 15W maximum) (1, 2)

FTA
Flat Adjustable Housing

NC1
New Construction All-in-One

NCCP
Chicago Plenum

NCIC
Insulation Contact Rated / Airtight

Voltage Options
Select one

UNV
120V-277V

120V

347V

Dimming Driver Options

For use with Universal Voltage 120V - 277V

No Additional Charge

D22
ERP 0-10V, 1% (2)

D6E
EldoLED 0-10V, 1% (4)

D6F
EldoLED 0-10V, 1% (4)

D4A
Lutron ECO, 0.1% (1, 2, 4)

D4E
Lutron 5 ECO, 5% (1, 2, 3, 4)

D4H
Lutron H ECO, 1% Fade (1, 2, 3, 4)

D4P
Lutron ECO, 1% (4)

D6A
EldoLED 0-10V, 0.1% (4)

D6B
EldoLED 0-10V, 0.1% (4)

D7
EldoLED DALI, 0.1% (4)

D18
Moons' DMX, 0.1% (2, 3, 4, 8)

For use with 120V only

No Additional Charge

D19
Phase 2-wire, 1% (1, 2)

D22
ERP Phase 2-wire, 1% (2)

D3
Lutron 2-wire, 1% (4, 6)

For use with 347V only

D15
0-10V dim, 1% 347V only (1, 2, 3, 4)

Accessories (Optional)*

CB27
27" C-Channel Bars

CB32
32" C-Channel Bars

CB52
52" C-Channel Bars

CM27
27" C-Channel Bars (use with FT and FTIC housings only)

CM52
52" C-Channel Bars (use with FT and FTIC housings only)

EM
Emergency Battery (7)

EMW
Emergency Battery Wet Location (7)

* Residential grade nailer bars provided standard

Notes:
1 Not available for Warm Glow.
2 Not available for Color Select
3 Not available with 9W
4 Not available with FT or FTIC housing
5 Not available with NCIC housing
6 Use only up to 15W max with NCIC housing
7 Not available with 347V. NC1 housing only. Requires above ceiling access for service
8 Not available in trimless and millwork

TRIM FINISH OPTIONS

White | Grey | Black | Bronze | Custom RAL (example) | Custom RAL (example)

Custom colors and primer finish also available

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T: 845-565-8500 F: 845-561-1130
info@usailighting.com

BeveLED Mini® Complete - B3RD
3" Round Downlight with Remote Driver

USAI Lighting

1. Specify fixture part number. (All boxes must be filled in to correctly order)

B3RD__

BeveLED Trim Style

F Trimmed with Flange (use with all materials)

L Trimless Spackle-in (use with sheetrock and plaster only)

M Millwork Knife-Edge (use with wood and stone)

Wattage Options

Classic White Light

09X3 9W LED

15X3 15W LED

20X3 20W LED

Warm Glow Dimming

15WG2 15W LED

20WG2 20W LED

LED Color Options

27KS 2700K, 80+ CRI

27KH 2700K, 90+ CRI

27KU 2700K, 95+ CRI

30KS 3000K, 80+ CRI

30KH 3000K, 90+ CRI

30KU 3000K, 95+ CRI

35KS 3500K, 80+ CRI

35KH 3500K, 90+ CRI

35KU 3500K, 95+ CRI

40KS 4000K, 80+ CRI

40KH 4000K, 90+ CRI

40KU 4000K, 95+ CRI

2722KS 2700K-2200K, 80+ CRI

2722KH 2700K-2200K, 90+ CRI

3022KS 3000K-2200K, 80+ CRI

3022KH 3000K-2200K, 90+ CRI

3522KS 3500K-2200K, 80+ CRI

Beam Options

40 40° beam

55 55° beam

65 65° beam

45 45° beam

55 55° beam

65 65° beam

Lens Options

S Solite (provided standard)

SF Solite Frosted

BF Borosilicate Frosted

Bevel Trim Finish Options

WH White

SC Conduit Silver

GR Grey

BL Black

BZ Bronze

PR Primer Finish

AC Clear Matte Anodized

AB Piano Gloss Black

RAL Custom Color Specify RAL #

*Flange/ Millwork Collar Finish

WH White

SC Conduit Silver

GR Grey

BL Black

BZ Bronze

PR Primer Finish

AC Clear Matte Anodized

WH White

BL Black

GR Grey

BZ Bronze

AB Piano Gloss Black

WH White

GR Grey

BL Black

BZ Bronze

RAL Custom Color Specify RAL #

*Leave blank for Trimless

Housing Options

FT Flat Housing New Construction

FTIC Flat Housing IC-Rated (up to 15W maximum)

FTA Flat Adjustable Housing

NC1 New Construction All-in-One

NCCP Chicago Plenum

NCIC Insulation Contact Rated / Airtight

RM

Remote Dimming Driver

RM Remote Dimming Driver, specify remote power supply in table below

Accessories (Optional)

CB27 27" C-Channel Bars

CB32 32" C-Channel Bars

CB52 52" C-Channel Bars

CM27 27" C-Channel Bars (use with FT and FTIC housings only)

CM52 52" C-Channel Bars (use with FT and FTIC housings only)

* Residential grade nailer bars provided standard

USAI Power Supply Must Be Specified

2. Specify Remote Power Supply

RPB-01

Remote Power Supply

RPB-01 BeveLED Mini Remote Power Supply

Wattage Options

Classic White

09X3 9W LED

15X3 15W LED

20X3 20W LED

Warm Glow

15WG2 15W LED

20WG2 20W LED

Voltage

UNV 120V - 277V

120V 120V Only

Remote Dimming Type and Level

D4A Lutron ECO, 0.1% (1)

D4E Lutron 5 ECO, 5% (1, 2)

D4H Lutron H ECO, 1% Fade (1, 2)

D4P Lutron ECO, 1%

D6A EldoLED 0-10V, 0.1%

D6B EldoLED 0-10V, 0.1%

D6E EldoLED 0-10V, 1%

D6F EldoLED 0-10V, 1%

D7 EldoLED DALI, 0.1%

D18 Moons DMX, 0.1% (2)

D3 Lutron 2-wire, 1%

D19 Hatch Phase 2-wire, 1% (1)

1 Not available for Warm Glow 2 Not available for 9W

Remote Emergency Option

EM7 EM battery requires remote enclosure by others, minimum size 14.5" L x 6.5" W x 3" H

NOTE:
Remote Power Supplies Require Enclosures by Others.
See Page 6 for Details.

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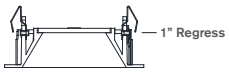
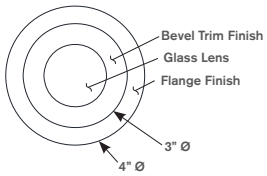
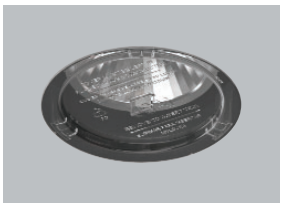
Trimmed - B3RDF

TRIM DETAILS

Trimmed - B3RDF



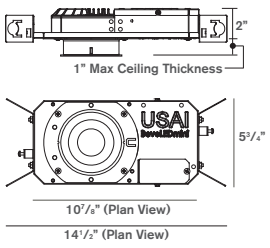




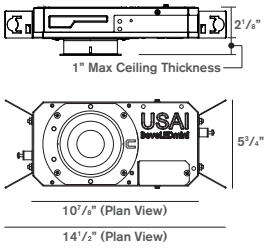
Clear acrylic overspray protector provided standard with every housing to keep out dust and contaminants during construction. Allows for use as work light.

HOUSING OPTIONS

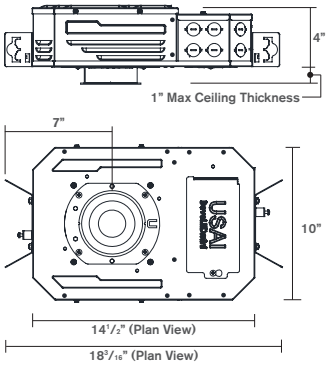
Flat Housing - FT



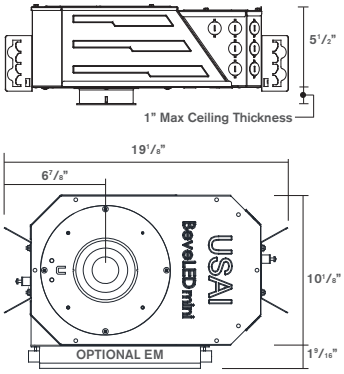
Flat Housing, IC-Rated - FTIC
(up to 15W maximum)



Flat Adjustable Housing - FTA



New Construction Housing - NC1
Insulation-Contact Rated - NCIC
Chicago Plenum Rated - NCCP



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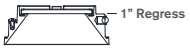
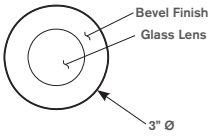
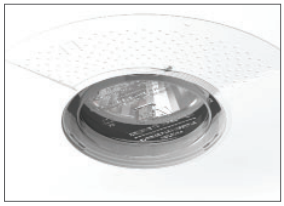
Trimless - B3RDL

TRIM DETAILS

Trimless - B3RDL



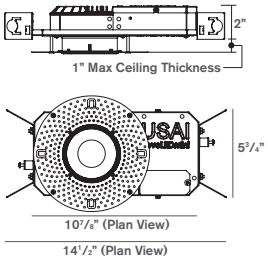




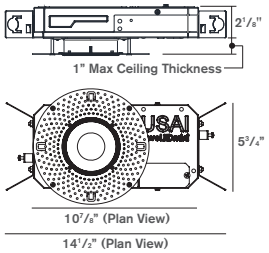
Clear acrylic overspray protector provided standard with every housing to keep out dust and contaminants during construction. Allows for use as work light.

HOUSING OPTIONS

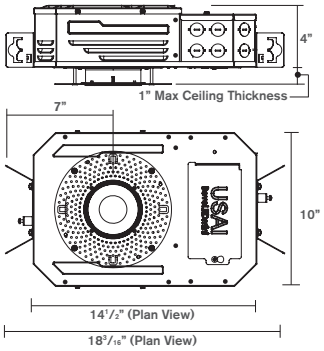
Flat Housing - FT



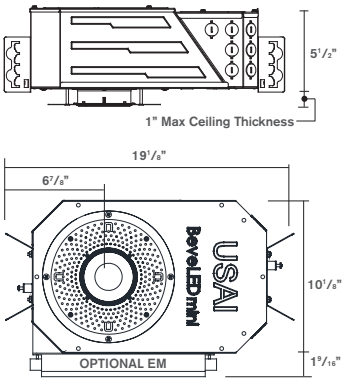
Flat Housing, IC-Rated - FTIC
(up to 15W maximum)



Flat Adjustable Housing - FTA



New Construction Housing - NC1
Insulation-Contact Rated - NCIC
Chicago Plenum Rated - NCCP



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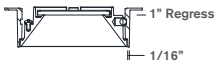
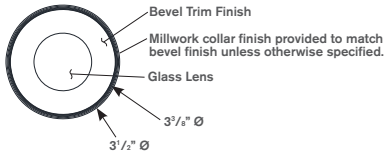
Millwork - B3RDM

TRIM DETAILS

Millwork - B3RAM

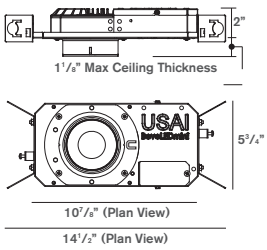




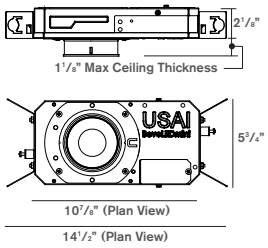
Clear acrylic overspray protector provided standard with every housing to keep out dust and contaminants during construction. Allows for use as work light.

HOUSING OPTIONS

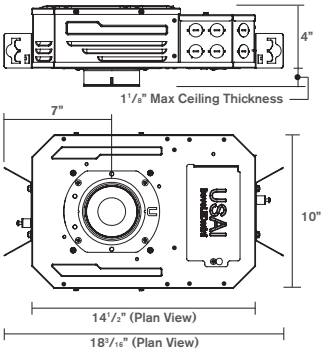
Flat Housing - FT



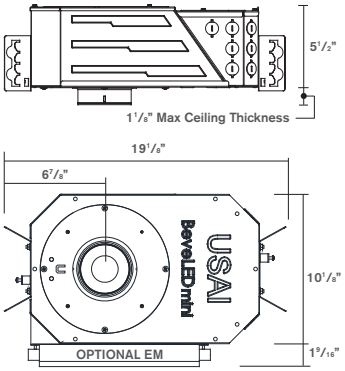
Flat Housing, IC-Rated - FTIC
(up to 15W maximum)



Flat Adjustable Housing - FTA



New Construction Housing - NC1
Insulation-Contact Rated - NCIC
Chicago Plenum Rated - NCCP



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BeveLED Mini® Complete - B3RD
3" Round Downlight

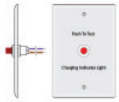
USAI® Lighting

BEVELED MINI SPECIFICATIONS

FIELD REPLACEABLE LED LIGHT ENGINE
is serviceable through the aperture with a Phillips screwdriver. All USAI Lighting light engines feature industry-leading color consistency.

FIELD REPLACEABLE INTEGRAL DRIVER
Unless otherwise specified, a 0-10V, 100%-1% solid state electronic constant current integral D22 dimming driver with a high power factor is provided standard and sources 2mA. All integral dimming drivers are located within the fixture housing and are serviceable from below the ceiling through the aperture. Some on-time delay may be experienced depending on control system used. All dimming drivers comply with IEEE C62.41 surge protection.

INTEGRAL EMERGENCY BATTERY
An integral emergency battery pack is available as an option with the NC1 housing and integral driver/power supply only. IOTA emergency battery provides backup power for 90 minutes. NC1 fixtures are provided with an integral emergency battery that requires above ceiling access for service, and a remote test switch, which comes with a 24" lead length for location of the test switch. Remote EM test switch is dry/damp only; select EMW emergency option for a wet location-rated EM test switch. Fixtures that have no USAI EM option may be connected to an inverter (by others) for emergency lighting. Battery is not available with 347V.



Remote Emergency Test Switch included with NC1 housing and integral driver only. Above ceiling access required for service.

REMOTE LOCATION DRIVER
BeveLED Mini is available for use with remotely located driver. Driver is provided separately for remote location on site, enclosure to be provided by others. Remote dimming driver power supply option must be clearly specified in the "RP" table. Remote power supplies require enclosures by others that meet local codes and must be located in an accessible service panel within 100ft of the light fixture; see remote driver table below for coordination of enclosure sizes and wire gauges required. All dimming drivers comply with IEEE C62.41 surge protection.

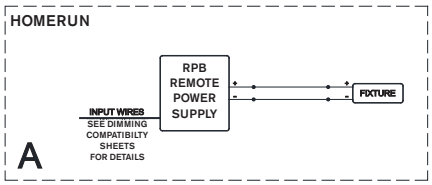
Remote Power Supply Requirements and Wiring Diagram
enclosure sizes and wire gauge with **1 fixture** per power supply.

Remote Power Supply	Dimming Option		Wire Gauge Required*	Minimum Enclosure Size Required (by others) RP Only	RP with EM Option**
RPB-01-09X3 RPB-01-15X3 RPB-01-20X3 RPB-01-15WG2 RPB-01-20WG2	**UNV-D4A**	Lutron ECO, 0.1% (1)	14/12	6.25" W x 4" L x 2" H	14.5" W x 6.5" L x 3" H
	UNV-D4E	Lutron 5 ECO, 5% (1, 2)			
	UNV-D4H	Lutron H ECO, 1% fade (1, 2)			
	UNV-D4P	Lutron ECO, 1%			
	UNV-D6A	EldoLED 0-10V, 0.1%	18/16		
	UNV-D6B	EldoLED 0-10V, 0.1%			
	UNV-D6E	EldoLED 0-10V, 1%			
	UNV-D6F	EldoLED 0-10V, 1%			
	UNV-D7	EldoLED DALI, 0.1%			
	UNV-D18	Moons DMX, 0.1% (2)			
	120V-D3	Lutron 2-wire phase, 1%	14/12	5.75" W X 2.625" L x 2" H	
	120V-D19	Hatch 2-wire phase, 1% (1)	14/12		

1 Not available for Warm Glow
2 Not available for 9W

Not all dimming options are availbale with all LED light engine options. See RP ordering table for details.
* Wire gauge 14/12 = Maximum distance from light fixture to remote power supply is 100' using 12 gauge wire, 50' using 14 gauge wire.
* Wire gauge 18/16 = Maximum distance from light fixture to remote power supply is 100' using 16 gauge wire, 50' using 18 gauge wire.
** Emergency battery remote power supplies cannot be located any more than 50 feet from light fixture.

Note: All light fixtures must be wired in homeruns per wiring diagram below.



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BeveLED Mini® Complete - B3RD
3" Round Downlight

USAI® Lighting

BEVELED MINI SPECIFICATIONS

HOUSING
All BeveLED Mini fixtures are field-flexible which allows for field changes from trimless or millwork to trimmed with a simple components change with parts from USAI. Housings are fabricated of 20 ga. steel construction with thru wire J-box, 4 in 4 out at min. 90°C, #12 AWG thru branch circuit wiring. FTIC and NCIC housing for use with 9W, 12W, and 15W light engines only are rated for direct contact with spray foam insulation of R-42 or less. FTIC housing is IC-rated up to 15W maximum.

MOUNTING
B3RDF overlap flange fixtures are designed for use in sheetrock, acoustical ceiling tile, and many other ceiling materials. B3RDL trimless fixtures are provided with a spackle collar and are designed for use in sheetrock/mud-in ceiling applications. B3RDM millwork fixtures are provided with a millwork collar and are designed for use in wood/millwork and stone construction applications. Butterfly brackets and residential grade adjustable nailer bars extendible from 14" to 24" centers with integral nails are provided standard for attachment to building structure. C-channel bars are optionally available for acoustical ceiling applications. If channel bars are specified for FT or FTIC housing, special reduced height channel bars (CM27 or CM52) will be provided.

Residential-grade nailer bars provided standard.

FIXTURE WEIGHT
FT and FTIC housings weigh 4 lbs. FTA housing weighs 10 lbs. NC1, NCIC, and NCCP housings weigh 11 lbs. NC1 housing with EM weighs 14 lbs.

WARRANTY
Based on IESNA LM80-2008, BeveLED has a 50,000 hour rated life at 70% lumen maintenance (L70). USAI Lighting Warranty covers replacement parts for 5 years from date of shipment. Ambient temperatures at fixture location should not exceed 40°C during normal operation.

CEILING CUT OUT
B3RDF Trimmed with Overlap Flange: 3-5/8"Ø
B3RDL Trimless Spackle-in: 4-3/16"Ø
B3RDM Millwork Knife-edge: 3-9/16"Ø

LISTINGS
Dry/Damp/Wet location. AC and AB trim finishes are dry/damp only. EM test switch is dry/damp only. Select EMW option for wet location remote test switch. UL2043 rated for use in air handling plenums. NRTL/CSA-US tested to UL standards. IBEW union made.

NOTES
- Not for use in corrosive environment
- Use of pressure washer voids warranty

PHOTOMETRICS
Consult factory or website for IES files. Tested in accordance with IESNA LM79.

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BeveLED Mini® Complete - B3RD
3" Round Downlight

USAI® Lighting

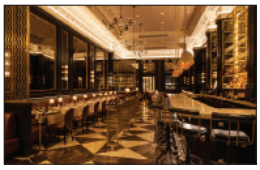
LED COLOR OPTIONS

Classic White Light

Our proprietary LED light engines achieve a 2-step MacAdam ellipse along the black body locus, resulting in reliable and uniform color from fixture to fixture. You'll see the results in consistently beautiful light throughout your space, whichever USAI LED product you specify.


Warm Glow® Dimming

Warm Glow Dimming provides warmth and glow once possible only in dimmed incandescent sources. Utilizing our patented proprietary algorithm and circuitry, Warm Glow Dimming technologies precisely mimic the black body curve of a standard 100W A19 lamp by gradually transitioning from 2700K , 3000K or 3500K down to 2200K. The result is virtually indistinguishable from an incandescent light source.

Color Select® Tunable White

Color Select represents the next innovation in color temperature control for advanced LED recessed downlighting. Color Select® products allow users to adjust color temperature from 6000K down to 2200K while independently adjusting intensity to achieve ultimate control over the quality of light in a space with a single fixture type. Color Select interfaces with standard dimming and control systems.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USAI Lighting

DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D3 / DIML3

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

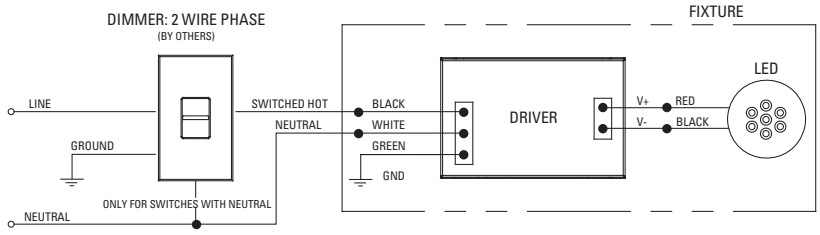
D3 / DIML3 LED: Lutron Hi-Lume A-Series 2 Wire Fwd Phase (with neutral) / LED Dimming Driver Wiring (Dims down to 1%) 120V

D3 / DIML3 Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Dimmer* Fixture Wattage	
120V Only				39W and Less	40W - 80W
ETC	Sensor+ Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
ETC	Unison DRd Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
Lutron	Maestro Wireless® 600W dimmer	MRF2-6ND-120-	100% - 1%	1 – 8	1 – 4
Lutron	Maestro Wireless® 1000W dimmer	MRF2-10ND-120-	100% - 1%	1 – 13	1 – 6
Lutron	HomeWorks® QS adaptive dimmer	HQRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 600W dimmer	HQRD-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 1000 W dimmer	HQRD-10ND-	100% - 1%	1 – 13	1 – 6
Lutron	Caseta Wireless® Pro 1000W dimmer	PD-10NXD-	100% - 1%	1 – 13	1 – 6
Lutron	Stanza® dimmer	SZ-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 adaptive dimmer	RRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 1000 W dimmer	RRD-10ND-	100% - 1%	1 – 6	1 – 3
Lutron	myRoom DIN power module	MQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® QS wallbox power module	HQRJ-WPM-6D-120-	100% - 1%	1 – 26	1 – 13
Lutron	Homeworks® DIN power module	LQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® wallbox power module	HWI-WPM-6D-120	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® QS control unit	QSGR-, QSGRJ-	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® 3000 control unit	GRX-3100-, GRX-3500-	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4U module	HW-RPM-4U-120, LP-RPM-4U-120	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4A module	HW-RPM-4A-120, LP-RPM-4A-120	100% - 1%	1 – 26	1 – 13
Lutron	GP dimming panels	Various	100% - 1%	1 – 26	1 – 13
Lutron	Ariadni CL 250W dimmer	AYCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Diva CL 250W dimmer	DVCL-253P-, DVSCCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Grafik T CL or RF CL dimmer	GT-250M-, GTJ-250M-	100%-1%	1 – 8	1 – 4
Lutron	Nova T CL 250W dimmer	NTCL-250-	100%-1%	1 – 10	1 – 5

* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D3 / DIML3
2 WIRE PHASE DIMMING



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I2-264-3 Revised 03/22/2017

DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D4A / DIML4A and D4P / DIML4P

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

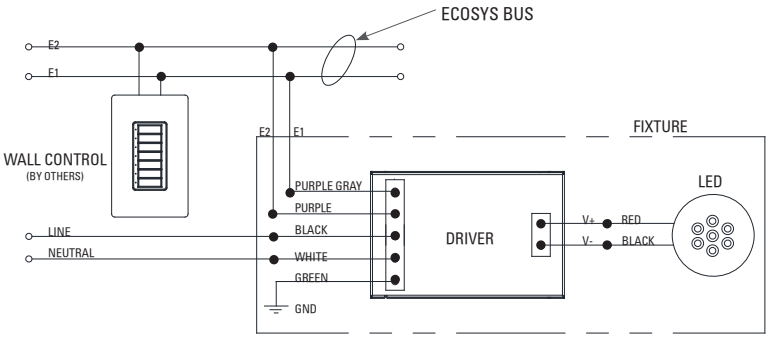
D4A / DIML4A LED: Lutron Hi-Lume Premier EcoSystem LED Driver (Dims down to 0.1%)
D4P / DIML4P LED: Lutron Hi-Lume Premier EcoSystem LED Driver (Dims down to 1%)

D4A / D4P EcoSystem Controls Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Maximum Quantity Light Fixtures Per Control
120V / 277V			
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	32
		FCJ/FCJS-ECO	3
120V ONLY			
Lutron	Energi Savr Node	QSN-1ECO-S	64
		QSN-2ECO-S	128
	GRAFIK Eye QS/ Homeworks QS control unit	QSGRJ-_ E, QSGR-_ E	64
	Quantum Hub	QP2-__2C	128
		QP2-__4C	256
		QP2-__6C	384
		QP2-__8C	512
	HomeWorks QS / myRoom Plus power module	LQSE-2ECO-D	128

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D4A / DIML4A and D4P / DIML4P
EcoSystem CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D4E / DIML4E and D4H /DIML4H

DIMMING DRIVER WIRING SCHEMES:

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4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D4E / DIML4E LED: Lutron 5 Series EcoSystem LED Driver / LED Dimming Driver Wiring (Dims down to 5%)

D4E / DIML4E EcoSystem Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V / 277V				39W and Less	40W - 80W
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	100%–5%	1–32	1–16
Lutron	Energi Savr Node	QSN-1ECO-S, QSN-2ECO-S	100%–5%	1–64	1–32
Lutron	GRAFIK Eye QS (120V ONLY)	QSGRJ- E, QSGR- E	100%–5%	1–64	1–32
Lutron	Quantum	Various	100%–5%	1–64	1–32

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

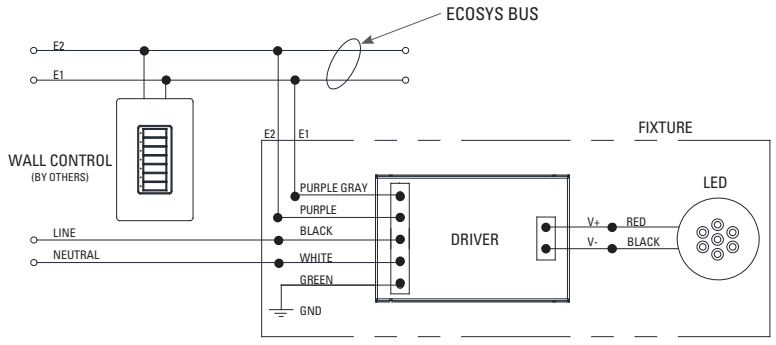
D4H / DIML4H LED: Lutron H Series EcoSystem LED Driver with Fade to Black (dims down to 1%)

D4H / DIML4H EcoSystem Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V / 277V				39W and Less	40W - 80W
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	100%–1%	1–32	1–16
Lutron	Energi Savr Node	QSN-1ECO-S, QSN-2ECO-S	100%–1%	1–64	1–32
Lutron	GRAFIK Eye QS (120V ONLY)	QSGRJ- E, QSGR- E	100%–1%	1–64	1–32
Lutron	Quantum	Various	100%–1%	1–64	1–32

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D4E / DIML4E and D4H / DIML 4H EcoSystem CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D6A / DIML6A and D6E / DIML6E
D6B / DIML6B and D6F / DIML6F

IMPORTANT SAFETY INSTRUCTIONS
- SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D6A / DIML6A and D6E / DIML6E LED Dimming Compatibility Table

D6A / DIML6A and D6E / DIML6E are linearly programmed dimming drivers for use with the dimming controls listed in the table below.
D6A / DIML6A = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1%
D6E / DIML6E = EldoLED ECOdrive 0-10V control dims from 100% to 1%

D6A / DIML6A and D6E / DIML6E Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range		Qty Fixtures Per Dimmer*
120V & 277V			DIML6A	6E	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Lutron	Diva	DVTV/NFTV with PP-20	99% - 0.1%	1%	
Lutron	Nova T	NTFTV with PP-20	99% - 0.1%	1%	
Lutron	Energi Savr Node	QSN-4T16-S	100% - 0.1%	1%	
Lutron	GP Dimming Panels	TVM2 Module	99% - 0.1%	1%	
Lutron	Interfaces	GRX-TVI w/ GRX3503	100% - 0.1%	1%	
Sensor Switch	nIO	nIO EZ	100% - 0.1%	1%	
enlighted	Control Unit	CU-3E-1R	100% - 0.1%	1%	

D6B / DIML6B and D6F / DIML6F LED Dimming Compatibility Table

D6B / DIML6B and D6F / DIML6F are logarithmic-programmed dimming drivers for use with the dimming controls listed in the table below.
D6B / DIML6B = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1% D6F / DIML6F = EldoLED ECOdrive 0-10V control dims from 100% to 1%

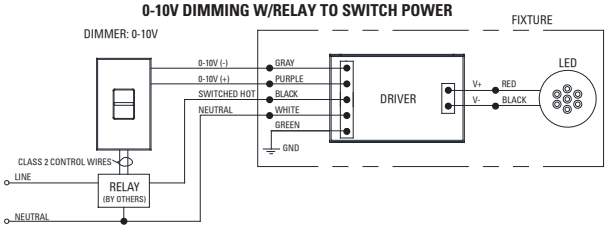
D6B / DIML6B and D6F / DIML6F Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range		Qty Fixtures Per Dimmer*
120V & 277V			DIML6B	6F	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Bush-Jaeger	Electronic potentiometer	2112U-101	100% - 0.1%	1%	
Jung	Electronic potentiometer	240-10	100% - 0.1%	1%	
Leviton	Iluma Tech dimmer	IP710-DLX	100% - 0.1%	1%	
Lightolier (Philips)	Momentum (120V ONLY)	ZP600FAM120	100% - 0.1%	1%	
Merten	Electronic potentiometer	5729	100% - 0.1%	1%	
Pass & Seymour	Titan	CD4FB-W	100% - 0.1%	1%	
Watt Stopper	Miro	DCLV1	100% - 0.1%	1%	
Synergy	Wallbox Dimmers	ISD BC	100% - 0.1%	1%	
ABB	i-bus	SD/S 2.16.1	100% - 0.1%	1%	
Crestron	Modules	GLX-DIMFLV8, GLXP-DIMFLV8	100% - 0.1%	1%	
Crestron	Green Light	GLPAC-DIMFLV4-, GLPAC-DIMFLV8-	100% - 0.1%	1%	
Crestron	Green Light Power Pack	GLPP-DIMFLVEX-PM, GLPP-1DIMFLV2EX-PM, GLPP-1DIMFLV3EX-PM	100% - 0.1%	1%	
Crestron	DIN Rail Analog Output Module	DIN-A08	100% - 0.1%	1%	
Crestron	DIN Rail 0-10V Fluorescent Dimmer	DIN-4DIMFLV4	100% - 0.1%	1%	
Crestron	iLux 0-10V Dimmer Expansion Module	CLS-EXP-DIMFLV	100% - 0.1%	1%	
enlighted	Control Unit	CU-3E-1R	100% - 0.1%	1%	

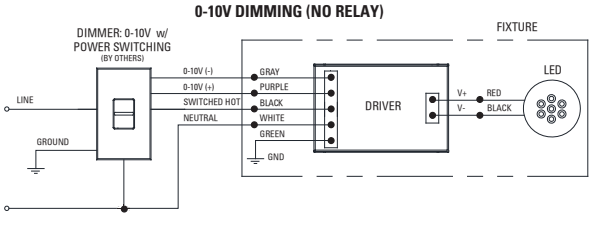
DIMMING DRIVER WIRING SCHEMES:

NOTES: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

D6 / DIML6
0-10V DIMMING W/RELAY TO SWITCH POWER



D6 / DIML6
0-10V DIMMING (NO RELAY)



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CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D7 / DIML7 and D7E

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

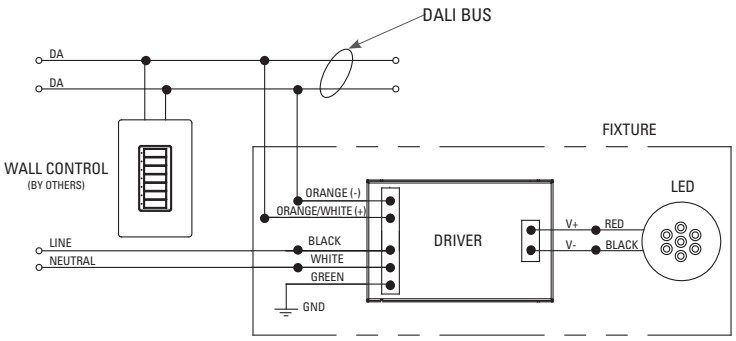
IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D7 / DIML7 and D7E Dimming Driver Wiring

D7 / DIML7 and D7E are linearly programmed dimming drivers.
D7 / DIML7 = EldoLED SOLOdrive DALI control dims from 100% to 0.1%
D7E = EldoLED ECOdrive DALI control dims from 100% to 1%

D7 / DIML7 / D7E
DALI CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D15 / DIML15

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
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4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

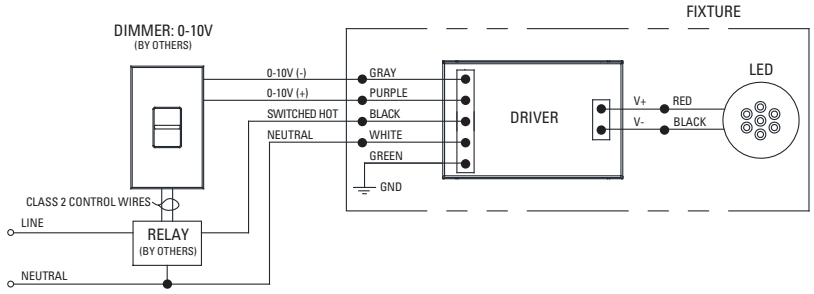
D15 / DIML15 LED: 0-10V, 347V Dimming Driver Wiring (Dims down to 1%) 347V Only

D15 / DIML15 Dimmer Compatibility Chart

Manufacturer	Product	Dimmed Light Output Range	Qty Fixtures Per Dimmer*
347			Use source current per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
Acuity	Synergy ISD-BC	100% - 1%	
Douglas Lighting	WPN-5721, WPN-5822	100% - 1%	
Hubbell	Light Hawk2 LHD-IRS3-N347-xx	100% - 1%	
Leviton	Illumatech IP710-DLZ with 347V relay	100% - 1%	
Leviton	Centura Fluorescent Control System	100% - 1%	
Lutron	Nova NFTV-* dimmer plus 347V relay	100% - 1%	
Lutron	Diva DVTV-* dimmer plus 347V relay	100% - 1%	

* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D15 / DIML15
0-10V DIMMING W/RELAY TO SWITCH POWER



NOTE:
If switched, non-dimming operation is desired, cap off purple and gray wires individually at installation. Do NOT cap purple and gray wires together.

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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D18

DIMMING DRIVER WIRING SCHEMES:

NOTES:

Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

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2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D18 Dimming Driver Wiring

D18 are programmed dimming drivers.
D18 Moons DMX control dims from 100% to 1%

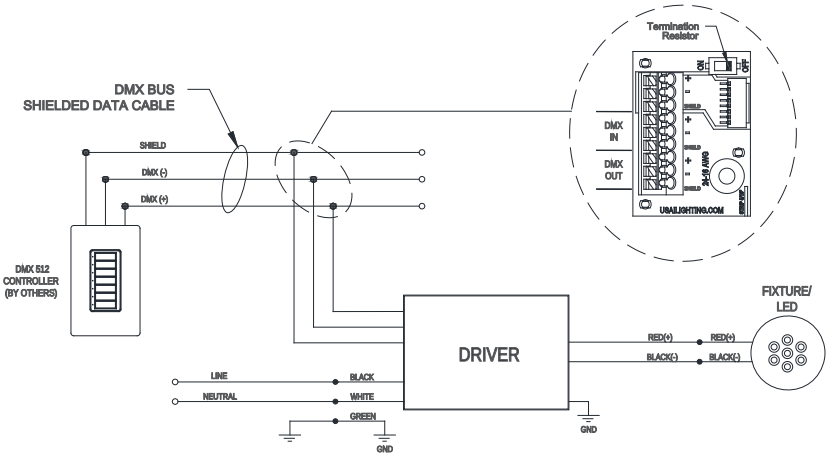
DMX BUS -
SHIELDED DATA CABLE

The data cable used must meet the following requirements:

- type: shielded, 2-conductor twisted pair
- maximum capacitance between conductors: 30 pF/ft
- maximum capacitance between conductor and shield: 55 pF/ft
- maximum resistance: 0.02 ohms/ft
- normal impedance: 100-140 ohms
- conductive core: 24 AWG is recommended

If 3-wire data cables are preferred, we suggest a Belden 9841 or equivalent cable which meets the specifications for EIA RS-485 applications. Do not use standard microphone cables: they cannot transmit DMX512 data reliably over long distances. NOTE: DMX link termination device, provided through Dip Switch on connection board, should be used on last fixture in line on a circuit to avoid signal loss.

D18
DMX CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D19 / DIML19

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
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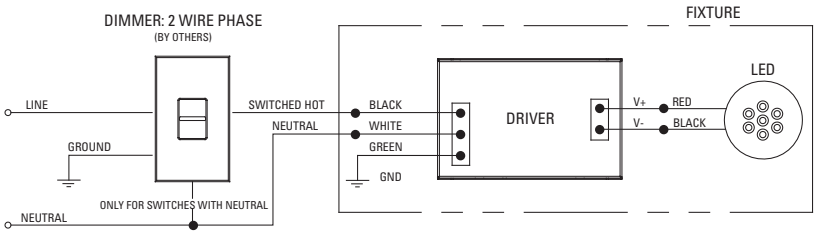
5. Cap any wires not used separately (not together).

D19 / DIML19 LED: Hatch XTC series or equivalent - Forward and Reverse Phase Dimming Driver. Dims down to 1% contingent upon dimmer specification and load. 120V only.

D19 / DIML19
2 WIRE PHASE DIMMING



D19 / DIML19 Dimmer Compatibility Chart

120V ONLY		
Forward Phase / TRIAC Dimming		
Manufacturer	Product	Qty Fixtures Per Dimmer
Leviton	IPL06-10Z	Use fixture wattage per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
	6613-xxx	
Lutron	S-600P	
	S-603P	
	DV-600P	
	DV-603P	
	DVSC-603P	
	CT-600P	
	CT-603P	

120V ONLY		
Reverse Phase / ELV Dimming		
Manufacturer	Product	Qty Fixtures Per Dimmer
Leviton	6615	Use fixture wattage per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
	IPE04-xxx	
Lutron	NTELV-300	
	NTELV-600	
	SELV-300P	
	SELV-303P	
	DVELV-300P	
	DVELV-303P	

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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D22

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

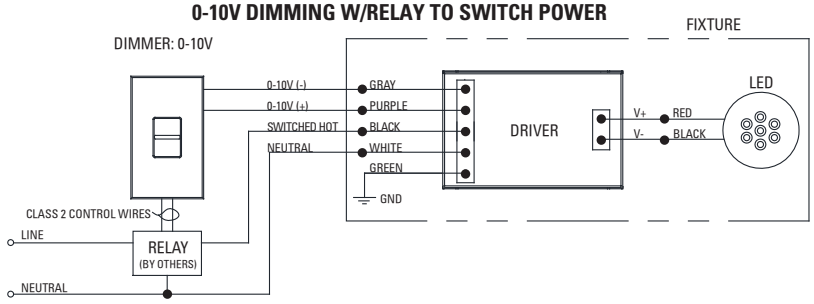
D22 LED: ERP ESS 0-10V Dimming Driver Wiring (Dims down to 1%)

D22 Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Dimmer*
120V / 277V				Use source current per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
Crestron	iLux dimmer expansion module	CLS-EXP-DIMFLV	100% - 1%	
Crestron	DIN Rail dimmer	DIN-4DIMFLV4	100% - 1%	
Crestron	DIN Rail analog output module	DIN-A08	100% - 1%	
Crestron	8 Channel dimmer module	GLX-DIMFLV8	100% - 1%	
Crestron	8 Channel dimmer module	GLXP-DIMFLV8	100% - 1%	
Leviton	IllumaTech dimmer	IP710-DLX	100% - 1%	
Lutron	Nova T	NFTV-XX	100% - 1%	
Lutron	Diva	DVTV-XX	100% - 1%	

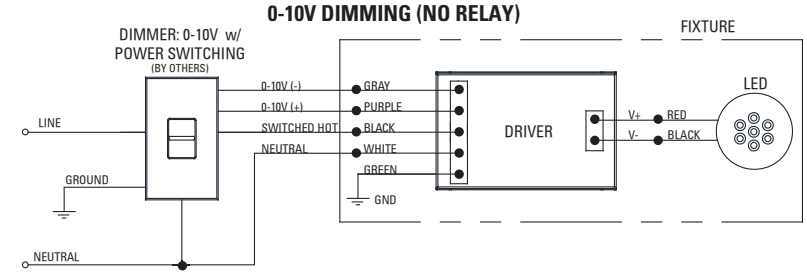
* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D22
0-10V DIMMING W/RELAY TO SWITCH POWER



NOTE:
If switched, non-dimming operation is desired, cap off purple and gray wires individually at installation. Do NOT cap purple and gray wires together.

D22
0-10V DIMMING (NO RELAY)



NOTE:
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DIMMING DRIVER WIRING SCHEMES:

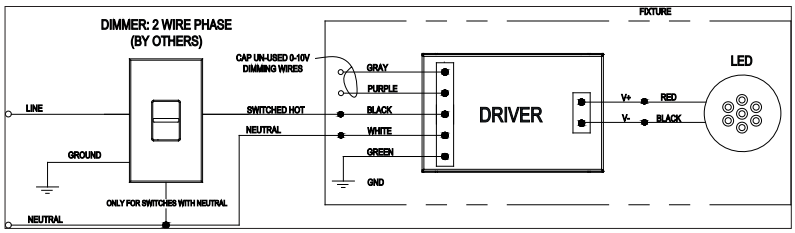
NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D22 LED: ERP ESS series or equivalent - Forward and Reverse Phase Dimming Driver.
Dims down to 1% contingent upon dimmer specification and load (see compatibility chart below). 120V only.

D22
2 WIRE PHASE DIMMING



D22 Dimmer Compatibility Chart

120V ONLY PHASE DIMMING				
Dimmer Information		Dimming Range		Qty Fixtures
Manufacturer	Product	Maximum	Minimum	Per Dimmer
Cooper	DAL06P	100%	0%	Use fixture wattage per fixture specification sheet to determine maximum number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating per dimmer specification sheet.
	DLC03P	100%	0%	
	SLC03P	100%	0%	
Leviton	6161	99%	10%	
	6631-2	100%	0%	
	6633-P	100%	0%	
	6673-10W	99%	6%	
	6683-IW	100%	2%	
	IPE04	100%	3%	
	IPI06-1LZ	99%	0%	
	VPE06	100%	5%	
Lightolier	ZP260QEW	99%	3%	
Lutron	CT103P	99%	6%	
	DV600P	99%	3%	
	DVCL-153P	99%	0%	
	DVELV303P	97%	3%	
	FAELV500	99%	7%	
	LG600P	99%	5%	
	MAELV600	99%	7%	
	S600P	99%	1%	
	S-603PG	86%	4%	
	SELV300P	97%	3%	
	TG-600P	99%	13%	
	TGCL-153P	99%	2%	

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USAI Lighting

COLOR SELECT®

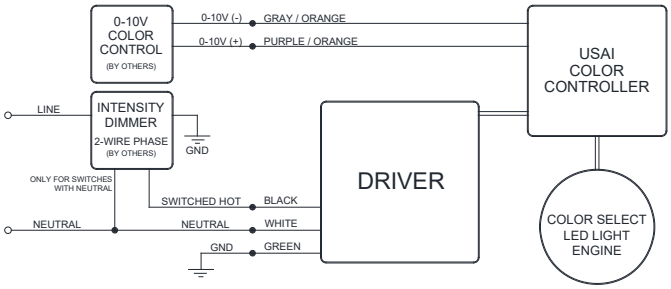
Covered By US Patents 8,581,520 and 8,456,109

INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML3

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML3 LED: Lutron Hi-Lume A-Series 2 Wire Fwd Phase (with neutral) / LED Dimming Driver Wiring (Dims down to 1%) 120V only.



D3 / DIML3 Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Dimmer* Fixture Wattage	
120V Only				39W and Less	40W - 80W
ETC	Sensor+ Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
ETC	Unison DRd Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
Lutron	Maestro Wireless® 600W dimmer	MRF2-6ND-120-	100% - 1%	1 – 8	1 – 4
Lutron	Maestro Wireless® 1000W dimmer	MRF2-10ND-120-	100% - 1%	1 – 13	1 – 6
Lutron	HomeWorks® QS adaptive dimmer	HQRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 600W dimmer	HQRD-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 1000 W dimmer	HQRD-10ND-	100% - 1%	1 – 13	1 – 6
Lutron	Caseta Wireless® Pro 1000W dimmer	PD-10NXD-	100% - 1%	1 – 13	1 – 6
Lutron	Stanza® dimmer	SZ-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 adaptive dimmer	RRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 1000 W dimmer	RRD-10ND-	100% - 1%	1 – 6	1 – 3
Lutron	myRoom DIN power module	MQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® QS wallbox power module	HQRJ-WPM-6D-120-	100% - 1%	1 – 26	1 – 13
Lutron	Homeworks® DIN power module	LQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® wallbox power module	HWI-WPM-6D-120	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® QS control unit	QSGR-, QSGRJ-	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® 3000 control unit	GRX-3100-, GRX-3500-	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4U module	HW-RPM-4U-120, LP-RPM-4U-120	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4A module	HW-RPM-4A-120, LP-RPM-4A-120	100% - 1%	1 – 26	1 – 13
Lutron	GP dimming panels	Various	100% - 1%	1 – 26	1 – 13
Lutron	Ariadni CL 250W dimmer	AYCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Diva CL 250W dimmer	DVCL-253P-, DVSCCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Grafik T CL or RF CL dimmer	GT-250M-, GTJ-250M-	100%-1%	1 – 8	1 – 4
Lutron	Nova T CL 250W dimmer	NTCL-250-	100%-1%	1 – 10	1 – 5

* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

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USAI Lighting

COLOR SELECT®

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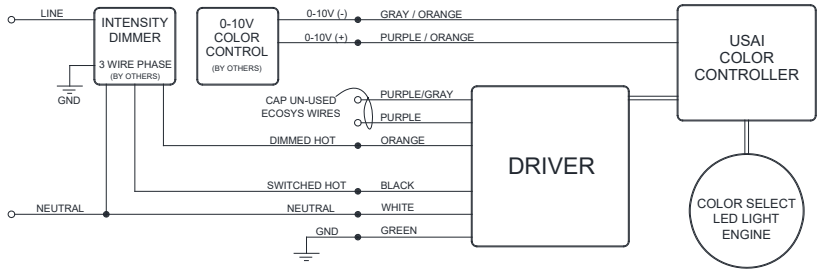
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML4

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML4 LED: Lutron Hi-Lume A-Series LED Driver with Eco System Control / LED Dimming Driver Wiring (Dims down to 1%)



D4 / DIML4 LED: Lutron Hi-Lume A-Series LED Driver with 3-Wire FL Control / LED Dimming Driver Wiring (Dims down to 1%)

D4 / DIML4 3-Wire Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V Only				39W and Less	40W - 80W
ETC	Sensor+ Cabinet	D20 Dimming module	100% - 1%	1–53	1–26
ETC	Unison DRd Cabinet	D20F Dimming module	100% - 1%	1–53	1–26
Lutron	Nova T	NTF-10-	100%–1%	1–41	1 – 20
Lutron	Nova T	NTF-103P-	100%–1%	1–20	1 – 10
Lutron	Nova	NF-10-	100%–1%	1–41	1 – 20
Lutron	Nova	NF-103P-	100%–1%	1–20	1 – 10
Lutron	Vareo	VF-10-	100%–1%	1–20	1 – 10
Lutron	Skylark	SF-10P-, SF-103P-	100%–1%	1–20	1 – 10
Lutron	Diva	DVF-103P-, DVSCF-103P-	100%–1%	1–20	1 – 10
Lutron	Ariadni	AYF-103P-	100%–1%	1–20	1 – 10
Lutron	Vierti	VTF-6A-	100%–1%	1–15	1 – 7
Lutron	Maestro	MAF-6AM-, MSCF-6AM-	100%–1%	1–15	1 – 7
Lutron	Maestro Wireless	MRF2-F6AN-DV-	100%–1%	1–15	1 – 7
Lutron	RadioRA 2	RRD-F6AN-DV-	100%–1%	1–15	1 – 7
Lutron	HomeWorks QS	HQRD-F6AN-DV	100%–1%	1–15	1 – 7
Lutron	Interfaces	PHPM-3F-120, PHPM-3F-DV	100%–1%	1–41	1 – 20
Lutron	GP Dimming Panels	Various	100%–1%	1–41	1 – 20
277V Only				40W and Less	41W - 80W
ETC	Sensor+ Cabinet	D20 Dimming module	100% - 1%	1–53	1–26
ETC	Unison DRd Cabinet	D20F Dimming module	100% - 1%	1–53	1–26
Lutron	Nova T	NTF-10-277-	100%–1%	1–44	1 – 22
Lutron	Nova T	NTF-103P-277-	100%–1%	1–33	1 – 16
Lutron	Nova	NF-10-277-	100%–1%	1–44	1 – 22
Lutron	Nova	NF-103P-277-	100%–1%	1–33	1 – 16
Lutron	Skylark	SF-12P-277-, SF-12P-277-3	100%–1%	1–33	1 – 16
Lutron	Diva	DVF-103P-277-, DVSCF-103P-277-	100%–1%	1–33	1 – 16
Lutron	Ariadni	AYF-103P-277-	100%–1%	1–44	1 – 22
Lutron	Vierti	VTF-6A-	100%–1%	1–33	1 – 16
Lutron	Maestro	MAF-6AM-277-, MSCF-6AM-277-	100%–1%	1–20	1 – 10
Lutron	Maestro Wireless	MRF2-F6AN-DV-	100%–1%	1–33	1 – 16
Lutron	RadioRA 2	RRD-F6AN-DV-	100%–1%	1–33	1 – 16
Lutron	HomeWorks QS	HQRD-F6AN-DV	100%–1%	1–33	1 – 16
Lutron	Interfaces	PHPM-3F-DV	100%–1%	1–88	1 – 44
Lutron	GP Dimming Panels	Various	100%–1%	1–88	1 – 44

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

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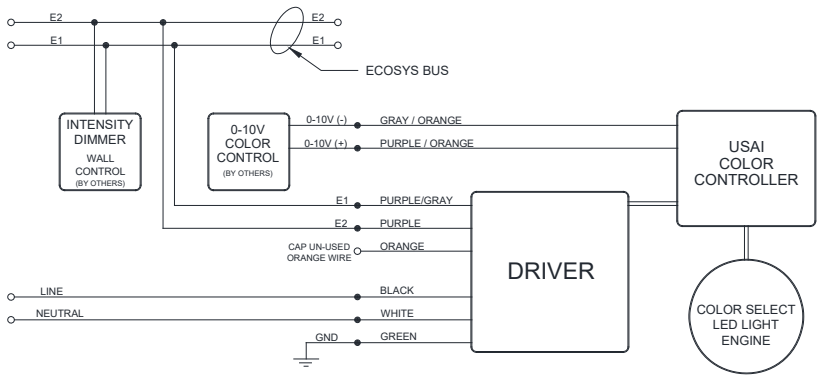
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML4 Continued

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML4 LED: Lutron Hi-Lume A-Series LED Driver with Eco System Control / LED Dimming Driver Wiring (Dims down to 1%)



D4 / DIML4 LED: Lutron Hi-Lume A-Series LED Driver with EcoSystem Control / LED Dimming Driver Wiring (Dims down to

D4 / DIML4 EcoSystem Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V / 277V				39W and Less	40W - 80W
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	100%–1%	1–32	1–16
Lutron	Energi Savr Node	QSN-1ECO-S, QSN-2ECO-S	100%–1%	1–64	1–32
Lutron	GRAFIK Eye QS (120V ONLY)	QSGRJ- E, QSGR- E	100%–1%	1–64	1–32
Lutron	Quantum	Various	100%–1%	1–64	1–32

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

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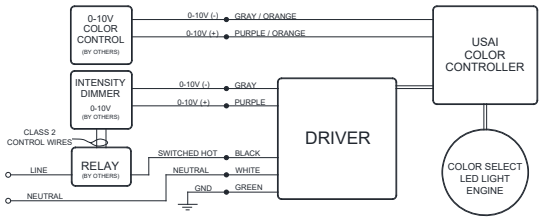
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML6A & 6B
DIML6E & DIML6F

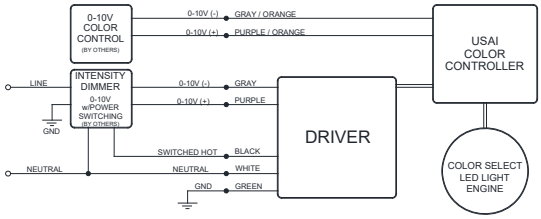
INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

0-10V Dimming w/ Relay Switch to Power



0-10V Dimming



D6A / DIML6A and D6E / DIML6E LED Dimming Compatibility Table

D6A / DIML6A and D6E / DIML6E are linearly programmed dimming drivers for use with the dimming controls listed in the table below
D6A / DIML6A = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1%
D6E / DIML6E = EldoLED ECOdrive 0-10V control dims from 100% to 1%

D6A / DIML6A and D6E / DIML6E Dimmer Compatibility Chart					
Manufacturer	Product	Part Number	Dimmed Light Output Range		Qty Fixtures Per Dimmer*
120V & 277V			DIML6A	6E	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Lutron	Diva	DVTV/NFTV with PP-20	99% -	0.1% 1%	
Lutron	Nova T	NTFTV with PP-20	99% -	0.1% 1%	
Lutron	Energi Savr Node	QSN-4T16-S	100% -	0.1% 1%	
Lutron	GP Dimming Panels	TVM2 Module	99% -	0.1% 1%	
Lutron	Interfaces	GRX-TVI w/ GRX3503	100% -	0.1% 1%	
Sensor Switch	nIO	nIO EZ	100% -	0.1% 1%	
enlighted	Control Unit	CU-3E-1R	100% -	0.1% 1%	

D6B / DIML6B and D6F / DIML6F LED Dimming Compatibility Table

D6B / DIML6B and D6F / DIML6F are logarithmic-programmed dimming drivers for use with the dimming controls listed in the table below
D6B / DIML6B = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1% D6F / DIML6F = EldoLED ECOdrive 0-10V control dims from 100% to 1%

D6B / DIML6B and D6F / DIML6F Dimmer Compatibility Chart					
Manufacturer	Product	Part Number	Dimmed Light Output Range		Qty Fixtures Per Dimmer*
120V & 277V			DIML6B	6F	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Bush-Jaeger	Electronic potentiometer	2112U-101	100% -	0.1% 1%	
Jung	Electronic potentiometer	240-10	100% -	0.1% 1%	
Leviton	Illuma Tech dimmer	IP710-DLX	100% -	0.1% 1%	
Lightolier (Philips)	Momentum (120V ONLY)	ZP600FAM120	100% -	0.1% 1%	
Merten	Electronic potentiometer	5729	100% -	0.1% 1%	
Pass & Seymour	Titan	CD4FB-W	100% -	0.1% 1%	
Watt Stopper	Miro	DCLV1	100% -	0.1% 1%	
Synergy	Wallbox Dimmers	ISD BC	100% -	0.1% 1%	
ABB	i-bus	SD/S 2.16.1	100% -	0.1% 1%	
Crestron	Modules	GLX-DIMFLV8, GLXP-DIMFLV8	100% -	0.1% 1%	
Crestron	Green Light	GLPAC-DIMFLV4-, GLPAC-DIMFLV8-	100% -	0.1% 1%	
Crestron	Green Light Power Pack	GLPP-DIMFLVEX-PM, GLPP-1DIMFLV2EX-PM, GLPP-1DIMFLV3EX-PM	100% -	0.1% 1%	
Crestron	DIN Rail Analog Output Module	DIN-A08	100% -	0.1% 1%	
Crestron	DIN Rail 0-10V Fluorescent Dimmer	DIN-4DIMFLV4	100% -	0.1% 1%	
Crestron	iLux 0-10V Dimmer Expansion Module	CLS-EXP-DIMFLV	100% -	0.1% 1%	
enlighted	Control Unit	CU-3E-1R	100% -	0.1% 1%	

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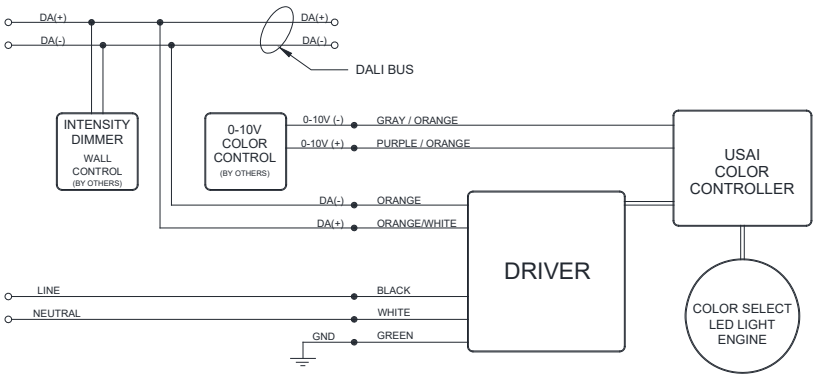
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML7

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML7 LED: eldoLED DALI dimming driver (dims down to 0.1%)



NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

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BeveLED Mini® Complete - B3RA
3" Round Adjustable

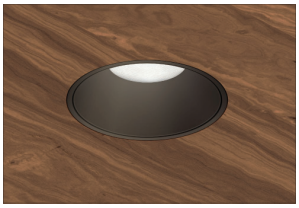
USAI Lighting

Universal and Field Convertible - Trim | Trimless | Millwork

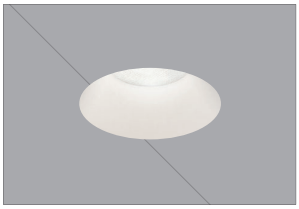
Trimmed - B3RAF

Trimless - B3RAL

Millwork - B3RAM



Trimless Acoustical Tile - B3RAP



usailighting.com/beveledmini

To specify Trimless Acoustical Lighting visit usailighting.com/B3RAP

Introducing new and improved BeveLED Mini, the smallest member of our iconic BeveLED family. BeveLED Mini has been infused with upgraded performance for superior light in every application. Now available with the following features, by popular demand:

FEATURES

- Upgraded performance and more LED color options than ever before!
- Field Flexibility - it's now easy to change trim in the field between trimmed, trimless and millwork
- Dry/damp/wet location rated for bathrooms and showers, including trimless and millwork
- More dimming options and all color technologies available
- Clear overspray protector for installation convenience
- Full family platform
- Iconic beveled look

ADJUSTABLE PERFORMANCE DATA

	LED COLOR CHOICES						
	Classic White			Warm Glow Dimming		Color Select	
DELIVERED* PERFORMANCE:	**9W**	**15W**	**20W**	**15W**	**20W**	**12W**	**18W**
Source Lumens:	1175	1825	2475	1350	1800	925	1200
Lumens Per Watt:	72	73	69	44	43	43	38
Delivered Lumens:	650	1025	1375	675	900	500	700

*Based on 3000K, 80+ CRI. Performance varies for each specific beamspread and color temperature. See IES files for exact values at usailighting.com.

CORRELATED COLOR TEMPERATURE MULTIPLIER	Classic White											
	2700K			**3000K**			**3500K**			**4000K**		
Color Rendering Index:	80+	90+	95+	80+	90+	95+	80+	90+	95+	80+	90+	95+
Multiplier for Lumen	0.96	0.81	0.70	1.00	0.86	0.74	1.03	0.88	0.79	1.06	0.81	0.81

	Warm Glow Dimming					Color Select						
	2700K		**3000K**		**3500K**	**2200K**	**2700K**	**3000K**	**3500K**	**4000K**	**5000K**	**6000K**
Color Rendering Index:	80+	90+	80+	90+	80+	80+	80+	80+	80+	80+	80+	80+
Multiplier for Lumen	1.00	0.78	1.00	0.83	1.05	0.92	0.97	1.00	1.03	1.05	1.10	1.13

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BeveLED Mini® Complete - B3RA
3" Round Adjustable with Integral Driver Housings

USAI Lighting

Specify fixture part number. (All boxes must be filled in to correctly order)

B3RA__

BeveLED Trim Style

F Trimmed with Flange (use with all materials)

L Trimless Spackle-in (use with sheetrock and plaster only)

M Millwork Knife-Edge (use with wood and stone)

Trim Choice

25 Horizontal trim lens, can be used for all tilt angles from 0°-40° (provided standard)

40 Optional cut-cone trim with canted lens, can be used for reduced clipping at tilt angles from 25°-40°

Wattage Options / LED Color Options

Classic White Light

Wattage Options	LED Color Options
09X3 9W LED	**27KS** 2700K, 80+ CRI
15X3 15W LED	**27KH** 2700K, 90+ CRI
20X3 20W LED	**27KU** 2700K, 95+ CRI
	30KS 3000K, 80+ CRI
	30KH 3000K, 90+ CRI
	30KU 3000K, 95+ CRI
	35KS 3500K, 80+ CRI
	35KH 3500K, 90+ CRI
	35KU 3500K, 95+ CRI
	40KS 4000K, 80+ CRI
	40KH 4000K, 90+ CRI
	40KU 4000K, 95+ CRI

Warm Glow Dimming

Wattage Options	LED Color Options
15WG2 15W LED	**2722KS** 2700K-2200K, 80+ CRI
20WG2 20W LED	**2722KH** 2700K-2200K, 90+ CRI
	3022KS 3000K-2200K, 80+ CRI
	3022KH 3000K-2200K, 90+ CRI
	3522KS 3500K-2200K, 80+ CRI

Color Select Tunable White

Wattage Options	LED Color Options
12CS1 12W LED	**6022KS** 6000K-2200K, Tunable White Light 80+ CRI
18CS1 18W LED (5)	

Beam Options

25 25° beam (2, 3)
30 30° beam
35 35° beam
40 40° beam
45 45° beam
50 50° beam (1)

Lens Options

S Solite (provided standard)
SF Solite Frosted
BF Borosilicate Frosted

Bevel Trim Finish Options / *Flange/ Millwork Collar Finish

Bevel Trim Finish Options	*Flange/ Millwork Collar Finish
WH White	**WH** White
SC Conduit Silver	**SC** Conduit Silver
GR Grey	**GR** Grey
BL Black	**BL** Black
BZ Bronze	**BZ** Bronze
PR Primer Finish	**PR** Primer Finish
AC Clear Matte Anodized	**AC** Clear Matte Anodized
	WH White
	BL Black
	GR Grey
	BZ Bronze
AB Piano Gloss Black	**AB** Piano Gloss Black
	WH White
	GR Grey
	BL Black
	BZ Bronze
RAL Custom Color Specify RAL #	**RAL** Custom Color Specify RAL #
	*Leave blank for Trimless

Housing Options

FTA Flat Adjustable Housing

NC1 New Construction All-in-One

NCCP Chicago Plenum

NCIC Insulation Contact Rated / Airtight

Voltage Options *Select one*

UNV 120V-277V

120V

347V

Dimming Driver Options

For use with Universal Voltage 120V - 277V

No Additional Charge

D22 ERP 0-10V, 1% (3)

D6E EldoLED 0-10V, 1%

D6F EldoLED 0-10V, 1%

D4A Lutron ECO, 0.1% (2, 3)

D4E Lutron 5 ECO, 5% (2, 3, 4)

D4H Lutron H ECO, 1% Fade (2, 3, 4)

D4P Lutron ECO, 1%

D6A EldoLED 0-10V, 0.1%

D6B EldoLED 0-10V, 0.1%

D7 EldoLED DALI, 0.1%

D18 Moons' DMX, 0.1% (3, 4, 8)

For use with 120V only

No Additional Charge

D19 Phase 2-wire, 1% (2, 3)

D22 ERP Phase 2-wire, 1% (3)

D3 Lutron 2-wire, 1% (6)

For use with 347V only

D15 0-10V dim, 1% 347V only (2, 3, 4)

Accessories (Optional)*

CB27 27" C-Channel Bars

CB32 32" C-Channel Bars

CB52 52" C-Channel Bars

HEXN Hex Cell Louver

EM Emergency Battery (7)

EMW Emergency Battery Wet Location (7)

* Residential grade nailer bars provided standard

Notes:
1 Not available with X3 LED
2 Not available for Warm Glow
3 Not available for Color Select.
4 Not available with 9W.
5 Not available with NCIC housing.
6 Use only up to 15W max with NCIC housing
7 Not available with 347V. NC1 housing only. Requires above ceiling access for service
8 Not available in trimless and millwork

TRIM FINISH OPTIONS

White | Grey | Black | Bronze | Custom RAL (example) | Custom RAL (example)

Custom colors and primer finish also available

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BeveLED Mini® Complete - B3RA
3" Round Adjustable with Remote Driver

USAI Lighting

1. Specify fixture part number. (All boxes must be filled in to correctly order)

B3RA__

BeveLED Trim Style
F Trimmed with Flange (use with all materials)

L Trimless Spackle-in (use with sheetrock and plaster only)

M Millwork Knife-Edge (use with wood and stone)

Trim Choice
25 Horizontal trim lens, can be used for all tilt angles from 0°-40° (provided standard)

40 Optional cut-cone trim with canted lens, can be used for reduced clipping at tilt angles from 25°-40°

Wattage Options / LED Color Options

Classic White Light

Wattage Options	LED Color Options
09X3 9W LED	**27KS** 2700K, 80+ CRI
15X3 15W LED	**27KH** 2700K, 90+ CRI
20X3 20W LED	**27KU** 2700K, 95+ CRI
	30KS 3000K, 80+ CRI
	30KH 3000K, 90+ CRI
	30KU 3000K, 95+ CRI
	35KS 3500K, 80+ CRI
	35KH 3500K, 90+ CRI
	35KU 3500K, 95+ CRI
	40KS 4000K, 80+ CRI
	40KH 4000K, 90+ CRI
	40KU 4000K, 95+ CRI

Warm Glow Dimming

Wattage Options	LED Color Options
15WG2 15W LED	**2722KS** 2700K-2200K, 80+ CRI
20WG2 20W LED	**2722KH** 2700K-2200K, 90+ CRI
	3022KS 3000K-2200K, 80+ CRI
	3022KH 3000K-2200K, 90+ CRI
	3522KS 3500K-2200K, 80+ CRI

Beam Options
25 25° beam (2)

30 30° beam

35 35° beam

40 40° beam

45 45° beam

50 50° beam (1)

Lens Options
S Solite (provided standard)

SF Solite Frosted

BF Borosilicate Frosted

Bevel Trim Finish Options / *Flange/ Millwork Collar Finish

Bevel Trim Finish Options	*Flange/ Millwork Collar Finish
WH White	**WH** White
SC Conduit Silver	**SC** Conduit Silver
GR Grey	**GR** Grey
BL Black	**BL** Black
BZ Bronze	**BZ** Bronze
PR Primer Finish	**PR** Primer Finish
AC Clear Matte Anodized	**AC** Clear Matte Anodized
	WH White
	BL Black
	GR Grey
	BZ Bronze
AB Piano Gloss Black	**AB** Piano Gloss Black
	WH White
	GR Grey
	BL Black
	BZ Bronze
RAL Custom Color Specify RAL #	**RAL** Custom Color Specify RAL #
	*Leave blank for Trimless

Housing Options
FTA Flat Adjustable Housing

NC1 New Construction All-in-One

NCCP Chicago Plenum

NCIC Insulation Contact Rated / Airtight

RM Remote Dimming Driver
RM Remote Dimming Driver, specify remote power supply in table below

Accessories (Optional)*
CB27 27" C-Channel Bars

CB32 32" C-Channel Bars

CB52 52" C-Channel Bars

HEXN Hex Cell Louver

* Residential grade nailer bars provided standard

USAI Power Supply Must Be Specified

Notes: 1 Not available with X3 LED
2 Not available for Warm Glow

2. Specify Remote Power Supply

RPB-01

Remote Power Supply
RPB-01 BeveLED Mini Remote Power Supply

Wattage Options
Classic White
- **09X3** 9W LED
- **15X3** 15W LED
- **20X3** 20W LED

Warm Glow
- **15WG2** 15W LED
- **20WG2** 20W LED

Voltage
UNV 120V - 277V

120V 120V Only

Remote Dimming Type and Level
- **D4A** Lutron ECO, 0.1% (2)
- **D4E** Lutron 5 ECO, 5% (2, 3)
- **D4H** Lutron H ECO, 1% Fade (2, 3)
- **D4P** Lutron ECO, 1%
- **D6A** EldoLED 0-10V, 0.1%
- **D6B** EldoLED 0-10V, 0.1%
- **D6E** EldoLED 0-10V, 1%
- **D6F** EldoLED 0-10V, 1%
- **D7** EldoLED DALI, 0.1%
- **D18** Moons DMX, 0.1% (3)
- **D3** Lutron 2-wire, 1%
- **D19** Hatch Phase 2-wire, 1% (2)

2 Not available for Warm Glow 3 Not available for 9W

Remote Emergency Option
EM7 EM battery requires remote enclosure by others, minimum size 14.5" L x 6.5" W x 3" H

NOTE:
Remote Power Supplies Require Enclosures by Others.
See Page 6 for Details.

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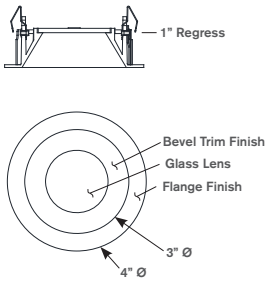
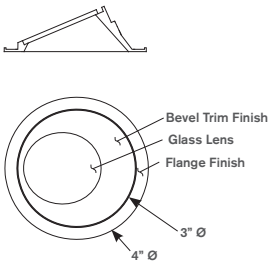
Trimmed - B3RAF

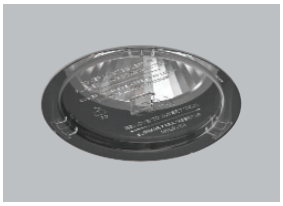
TRIM DETAILS

Trimmed - B3RAF-25



Trimmed - B3RAF-40

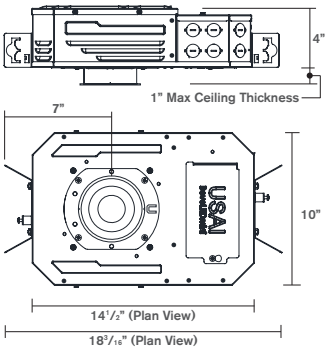




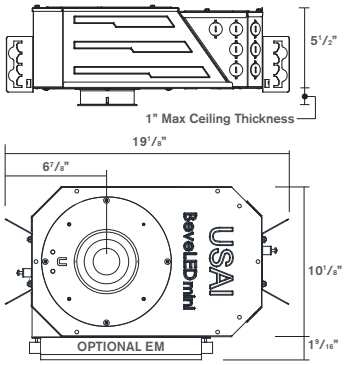
Clear acrylic overspray protector provided standard with every housing to keep out dust and contaminants during construction. Allows for use as work light.

HOUSING OPTIONS

Flat Adjustable Housing - FTA



New Construction Housing - NC1
Insulation-Contact Rated - NCIC
Chicago Plenum Rated - NCCP



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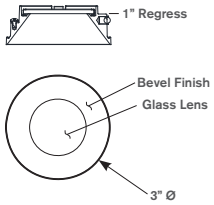
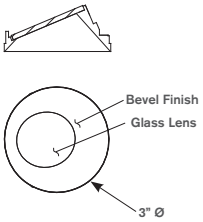
Trimless - B3RAL

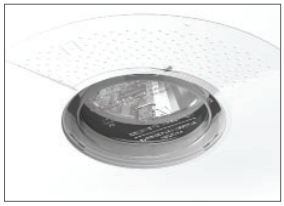
TRIM DETAILS

Trimless - B3RAL-25



Trimless - B3RAL-40





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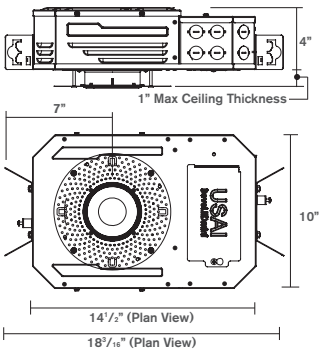
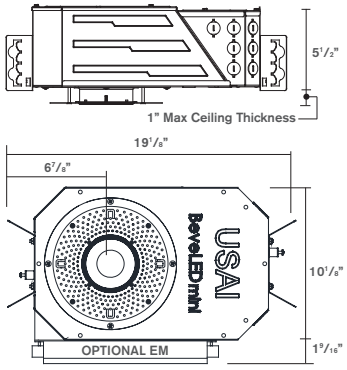
HOUSING OPTIONS

Flat Adjustable Housing - FTA



New Construction Housing - NC1
Insulation-Contact Rated - NCIC
Chicago Plenum Rated - NCCP



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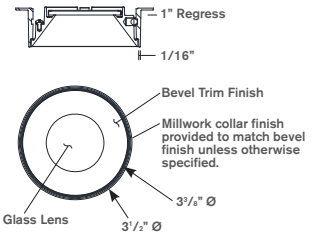
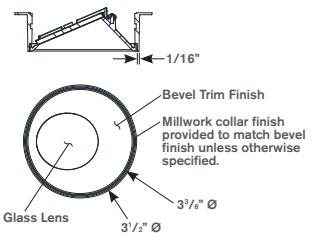
Millwork - B3RAM

TRIM DETAILS

Millwork - B3RAM-25



Millwork - B3RAM-40



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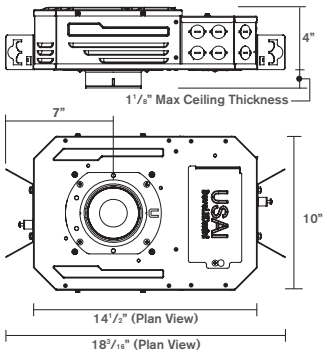
HOUSING OPTIONS

Flat Adjustable Housing - FTA



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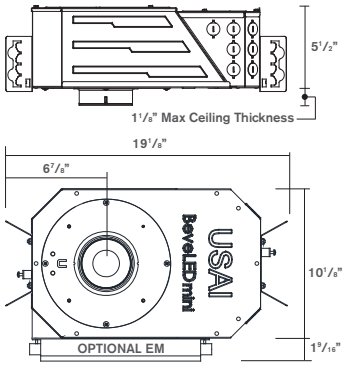
Insulation-Contact Rated - NCIC
Chicago Plenum Rated - NCCP



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BeveLED Mini® Complete - B3RA
3" Round Adjustable

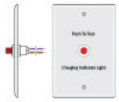
USAI® Lighting

BEVELED MINI SPECIFICATIONS

FIELD REPLACEABLE LED LIGHT ENGINE
is serviceable through the aperture with a Phillips screwdriver. All USAI Lighting light engines feature industry-leading color consistency.

FIELD REPLACEABLE INTEGRAL DRIVER
Unless otherwise specified, a 0-10V, 100%-1% solid state electronic constant current integral D22 dimming driver with a high power factor is provided standard and sources 2mA. All integral dimming drivers are located within the fixture housing and are serviceable from below the ceiling through the aperture. Some on-time delay may be experienced depending on control system used. All dimming drivers comply with IEEE C62.41 surge protection.

INTEGRAL EMERGENCY BATTERY
An integral emergency battery pack is available as an option with the NC1 housing and integral driver/power supply only. IOTA emergency battery provides backup power for 90 minutes. NC1 fixtures are provided with an integral emergency battery that requires above ceiling access for service, and a remote test switch, which comes with a 24" lead length for location of the test switch. Remote EM test switch is dry/damp only; select EMW emergency option for a wet location-rated EM test switch. Fixtures that have no USAI EM option may be connected to an inverter (by others) for emergency lighting. Battery is not available with 347V.



Remote Emergency Test Switch included with NC1 housing and integral driver only. Above ceiling access required for service.

REMOTE LOCATION DRIVER
BeveLED Mini is available for use with remotely located driver. Driver is provided separately for remote location on site, enclosure to be provided by others. Remote dimming driver power supply option must be clearly specified in the "RP" table. Remote power supplies require enclosures by others that meet local codes and must be located in an accessible service panel within 100ft of the light fixture; see remote driver table below for coordination of enclosure sizes and wire gauges required. All dimming drivers comply with IEEE C62.41 surge protection.

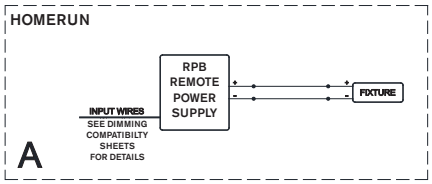
Remote Power Supply Requirements and Wiring Diagram
enclosure sizes and wire gauge with **1 fixture** per power supply.

Remote Power Supply Dimming Option			Wire Gauge Required*	Minimum Enclosure Size Required (by others) RP Only	RP with EM Option**
RPB-01-09X3 RPB-01-15X3 RPB-01-20X3 RPB-01-15WG2 RPB-01-20WG2	**UNV-D4A**	Lutron ECO, 0.1% (1)	14/12	6.25" W x 4" L x 2" H	14.5" W x 6.5" L x 3" H
	UNV-D4E	Lutron 5 ECO, 5% (1, 2)			
	UNV-D4H	Lutron H ECO, 1% fade (1, 2)			
	UNV-D4P	Lutron ECO, 1%			
	UNV-D6A	EldoLED 0-10V, 0.1%	18/16		
	UNV-D6B	EldoLED 0-10V, 0.1%			
	UNV-D6E	EldoLED 0-10V, 1%			
	UNV-D6F	EldoLED 0-10V, 1%			
	UNV-D7	EldoLED DALI, 0.1%			
	UNV-D18	Moons DMX, 0.1% (2)			
	120V-D3	Lutron 2-wire phase, 1%	14/12	5.75" W X 2.625" L x 2" H	
	120V-D19	Hatch 2-wire phase, 1% (1)	14/12		

1 Not available for Warm Glow
2 Not available for 9W

Not all dimming options are availbale with all LED light engine options. See RP ordering table for details.
* Wire gauge 14/12 = Maximum distance from light fixture to remote power supply is 100' using 12 gauge wire, 50' using 14 gauge wire.
* Wire gauge 18/16 = Maximum distance from light fixture to remote power supply is 100' using 16 gauge wire, 50' using 18 gauge wire.
** Emergency battery remote power supplies cannot be located any more than 50 feet from light fixture.

Note: All light fixtures must be wired in homeruns per wiring diagram below.



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BeveLED Mini® Complete - B3RA
3" Round Adjustable

USAI® Lighting

BEVELED MINI SPECIFICATIONS

TRIM
Adjustable fixtures are available with two trim options. The standard trim provided (-25-) has a horizontal trim lens and can be used for all tilt angles from 0°-40°. A cut-cone trim with a canted trim lens (-40-) is optionally available for reduced clipping at tilt angles from 25°-40°.

ADJUSTMENT
True hot aiming with center beam optics is adjustable, either tool-less or with a Phillips screwdriver. 0°-40° lockable vertical tilt with 362° lockable rotation.

ACCESSORY HOLDER
Snap in accessory holder shipped with fixture accomodates 1 accessory.

HOUSING
All BeveLED Mini fixtures are field-flexible which allows for field changes from trimless or millwork to trimmed with a simple components change with parts from USAI. Housings are fabricated of 20 ga. steel construction with thru wire J-box, 4 in 4 out at min. 90°C, #12 AWG thru branch circuit wiring. NCIC housing for use with 9W, 12W and 15W light engines only are rated for direct contact with spray foam insulation of R-42 or less.

MOUNTING
B3RAF overlap flange fixtures are designed for use in sheetrock, acoustical ceiling tile, and many other ceiling materials. B3RAL trimless fixtures are provided with a spackle collar and are designed for use in sheetrock/mud-in ceiling applications. B3RAM millwork fixtures are provided with a millwork collar and are designed for use in wood/millwork and stone construction applications. Butterfly brackets and residential grade adjustable nailer bars extendible from 14" to 24" centers with integral nails are provided standard for attachment to building structure. C-channel bars are optionally available for acoustical ceiling applications.

FIXTURE WEIGHT
FTA housing weighs 10 lbs. NC1, NCIC, and NCCP housings weigh 11 lbs. NC1 housing with EM weighs 14 lbs.

WARRANTY
Based on IESNA LM80-2008, BeveLED has a 50,000 hour rated life at 70% lumen maintenance (L70). USAI Lighting Warranty covers replacement parts for 5 years from date of shipment. Ambient temperatures at fixture location should not exceed 40°C during normal operation.

CEILING CUT OUT
B3RAF Trimmed with Overlap Flange: 3-5/8"Ø
B3RAL Trimless Spackle-in: 4-3/16"Ø
B3RAM Millwork Knife-edge: 3-9/16"Ø

LISTINGS
Dry/Damp/Wet location. AC and AB trim finishes are dry/damp only. EM test switch is dry/damp only. Select EMW option for wet location remote test switch. UL2043 rated for use in air handling plenums. NRTL/CSA-US tested to UL standards. IBEW union made.

NOTES
- Not for use in corrosive environment
- Use of pressure washer voids warranty

PHOTOMETRICS
Consult factory or website for IES files. Tested in accordance with IESNA LM79.

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BeveLED Mini® Complete - B3RA
3" Round Adjustable

USAI® Lighting

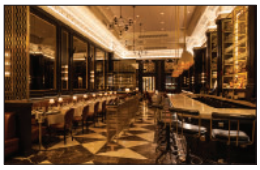
LED COLOR OPTIONS

Classic White Light

Our proprietary LED light engines achieve a 2-step MacAdam ellipse along the black body locus, resulting in reliable and uniform color from fixture to fixture. You'll see the results in consistently beautiful light throughout your space, whichever USAI LED product you specify.


Warm Glow® Dimming

Warm Glow Dimming provides warmth and glow once possible only in dimmed incandescent sources. Utilizing our patented proprietary algorithm and circuitry, Warm Glow Dimming technologies precisely mimic the black body curve of a standard 100W A19 lamp by gradually transitioning from 2700K , 3000K or 3500K down to 2200K. The result is virtually indistinguishable from an incandescent light source.

Color Select® Tunable White

Color Select represents the next innovation in color temperature control for advanced LED recessed downlighting. Color Select® products allow users to adjust color temperature from 6000K down to 2200K while independently adjusting intensity to achieve ultimate control over the quality of light in a space with a single fixture type. Color Select interfaces with standard dimming and control systems.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USAI Lighting

DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D3 / DIML3

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

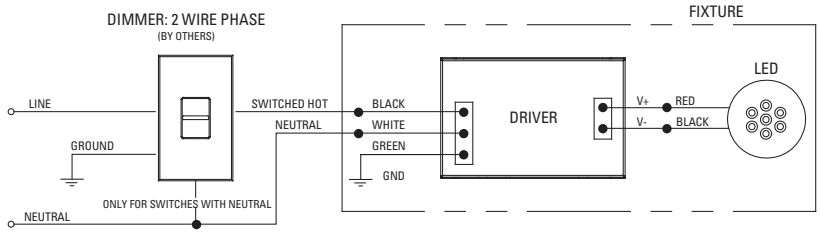
D3 / DIML3 LED: Lutron Hi-Lume A-Series 2 Wire Fwd Phase (with neutral) / LED Dimming Driver Wiring (Dims down to 1%) 120V

D3 / DIML3 Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Dimmer* Fixture Wattage	
120V Only				39W and Less	40W - 80W
ETC	Sensor+ Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
ETC	Unison DRd Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
Lutron	Maestro Wireless® 600W dimmer	MRF2-6ND-120-	100% - 1%	1 – 8	1 – 4
Lutron	Maestro Wireless® 1000W dimmer	MRF2-10ND-120-	100% - 1%	1 – 13	1 – 6
Lutron	HomeWorks® QS adaptive dimmer	HQRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 600W dimmer	HQRD-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 1000 W dimmer	HQRD-10ND-	100% - 1%	1 – 13	1 – 6
Lutron	Caseta Wireless® Pro 1000W dimmer	PD-10NXD-	100% - 1%	1 – 13	1 – 6
Lutron	Stanza® dimmer	SZ-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 adaptive dimmer	RRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 1000 W dimmer	RRD-10ND-	100% - 1%	1 – 6	1 – 3
Lutron	myRoom DIN power module	MQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® QS wallbox power module	HQRJ-WPM-6D-120-	100% - 1%	1 – 26	1 – 13
Lutron	Homeworks® DIN power module	LQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® wallbox power module	HWI-WPM-6D-120	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® QS control unit	QSGR-, QSGRJ-	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® 3000 control unit	GRX-3100-, GRX-3500-	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4U module	HW-RPM-4U-120, LP-RPM-4U-120	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4A module	HW-RPM-4A-120, LP-RPM-4A-120	100% - 1%	1 – 26	1 – 13
Lutron	GP dimming panels	Various	100% - 1%	1 – 26	1 – 13
Lutron	Ariadni CL 250W dimmer	AYCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Diva CL 250W dimmer	DVCL-253P-, DVSCCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Grafik T CL or RF CL dimmer	GT-250M-, GTJ-250M-	100%-1%	1 – 8	1 – 4
Lutron	Nova T CL 250W dimmer	NTCL-250-	100%-1%	1 – 10	1 – 5

* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D3 / DIML3
2 WIRE PHASE DIMMING



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I2-264-3 Revised 03/22/2017

DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D4A / DIML4A and D4P / DIML4P

DIMMING DRIVER WIRING SCHEMES:

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3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

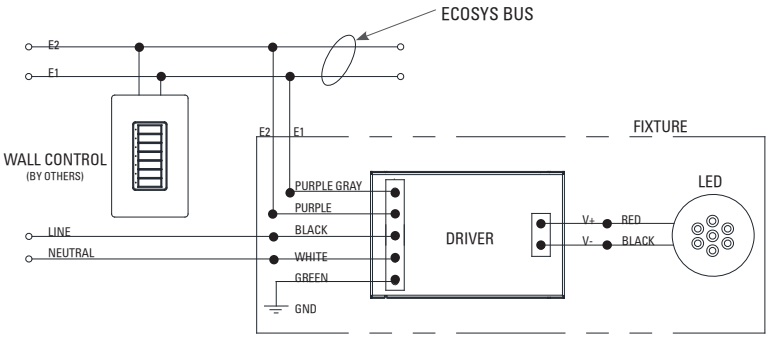
D4A / DIML4A LED: Lutron Hi-Lume Premier EcoSystem LED Driver (Dims down to 0.1%)
D4P / DIML4P LED: Lutron Hi-Lume Premier EcoSystem LED Driver (Dims down to 1%)

D4A / D4P EcoSystem Controls Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Maximum Quantity Light Fixtures Per Control
120V / 277V			
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	32
		FCJ/FCJS-ECO	3
120V ONLY			
Lutron	Energi Savr Node	QSN-1ECO-S	64
		QSN-2ECO-S	128
	GRAFIK Eye QS/ Homeworks QS control unit	QSGRJ-_ E, QSGR-_ E	64
	Quantum Hub	QP2-__2C	128
		QP2-__4C	256
		QP2-__6C	384
		QP2-__8C	512
	HomeWorks QS / myRoom Plus power module	LQSE-2ECO-D	128

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D4A / DIML4A and D4P / DIML4P
EcoSystem CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D4E / DIML4E and D4H /DIML4H

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D4E / DIML4E LED: Lutron 5 Series EcoSystem LED Driver / LED Dimming Driver Wiring (Dims down to 5%)

D4E / DIML4E EcoSystem Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V / 277V				39W and Less	40W - 80W
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	100%–5%	1–32	1–16
Lutron	Energi Savr Node	QSN-1ECO-S, QSN-2ECO-S	100%–5%	1–64	1–32
Lutron	GRAFIK Eye QS (120V ONLY)	QSGRJ- E, QSGR- E	100%–5%	1–64	1–32
Lutron	Quantum	Various	100%–5%	1–64	1–32

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

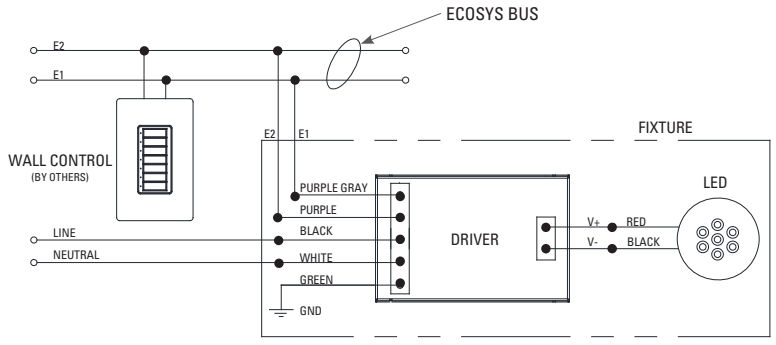
D4H / DIML4H LED: Lutron H Series EcoSystem LED Driver with Fade to Black (dims down to 1%)

D4H / DIML4H EcoSystem Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V / 277V				39W and Less	40W - 80W
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	100%–1%	1–32	1–16
Lutron	Energi Savr Node	QSN-1ECO-S, QSN-2ECO-S	100%–1%	1–64	1–32
Lutron	GRAFIK Eye QS (120V ONLY)	QSGRJ- E, QSGR- E	100%–1%	1–64	1–32
Lutron	Quantum	Various	100%–1%	1–64	1–32

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D4E / DIML4E and D4H / DIML 4H EcoSystem CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D6A / DIML6A and D6E / DIML6E
D6B / DIML6B and D6F / DIML6F

IMPORTANT SAFETY INSTRUCTIONS
- SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D6A / DIML6A and D6E / DIML6E LED Dimming Compatibility Table

D6A / DIML6A and D6E / DIML6E are linearly programmed dimming drivers for use with the dimming controls listed in the table below.
D6A / DIML6A = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1%
D6E / DIML6E = EldoLED ECOdrive 0-10V control dims from 100% to 1%

D6A / DIML6A and D6E / DIML6E Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range		Qty Fixtures Per Dimmer*
120V & 277V			DIML6A	6E	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Lutron	Diva	DVTV/NFTV with PP-20	99% - 0.1%	1%	
Lutron	Nova T	NTFTV with PP-20	99% - 0.1%	1%	
Lutron	Energi Savr Node	QSN-4T16-S	100% - 0.1%	1%	
Lutron	GP Dimming Panels	TVM2 Module	99% - 0.1%	1%	
Lutron	Interfaces	GRX-TVI w/ GRX3503	100% - 0.1%	1%	
Sensor Switch	nIO	nIO EZ	100% - 0.1%	1%	
enlighted	Control Unit	CU-3E-1R	100% - 0.1%	1%	

D6B / DIML6B and D6F / DIML6F LED Dimming Compatibility Table

D6B / DIML6B and D6F / DIML6F are logarithmic-programmed dimming drivers for use with the dimming controls listed in the table below.
D6B / DIML6B = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1% D6F / DIML6F = EldoLED ECOdrive 0-10V control dims from 100% to 1%

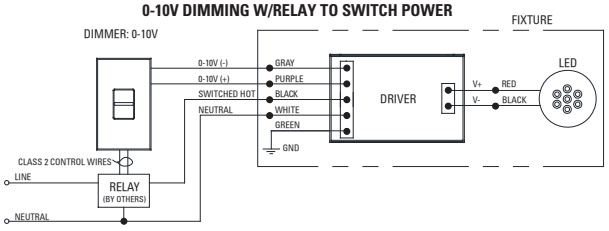
D6B / DIML6B and D6F / DIML6F Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range		Qty Fixtures Per Dimmer*
120V & 277V			DIML6B	6F	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Bush-Jaeger	Electronic potentiometer	2112U-101	100% - 0.1%	1%	
Jung	Electronic potentiometer	240-10	100% - 0.1%	1%	
Leviton	Iluma Tech dimmer	IP710-DLX	100% - 0.1%	1%	
Lightolier (Philips)	Momentum (120V ONLY)	ZP600FAM120	100% - 0.1%	1%	
Merten	Electronic potentiometer	5729	100% - 0.1%	1%	
Pass & Seymour	Titan	CD4FB-W	100% - 0.1%	1%	
Watt Stopper	Miro	DCLV1	100% - 0.1%	1%	
Synergy	Wallbox Dimmers	ISD BC	100% - 0.1%	1%	
ABB	i-bus	SD/S 2.16.1	100% - 0.1%	1%	
Crestron	Modules	GLX-DIMFLV8, GLXP-DIMFLV8	100% - 0.1%	1%	
Crestron	Green Light	GLPAC-DIMFLV4-, GLPAC-DIMFLV8-	100% - 0.1%	1%	
Crestron	Green Light Power Pack	GLPP-DIMFLVEX-PM, GLPP-1DIMFLV2EX-PM, GLPP-1DIMFLV3EX-PM	100% - 0.1%	1%	
Crestron	DIN Rail Analog Output Module	DIN-A08	100% - 0.1%	1%	
Crestron	DIN Rail 0-10V Fluorescent Dimmer	DIN-4DIMFLV4	100% - 0.1%	1%	
Crestron	iLux 0-10V Dimmer Expansion Module	CLS-EXP-DIMFLV	100% - 0.1%	1%	
enlighted	Control Unit	CU-3E-1R	100% - 0.1%	1%	

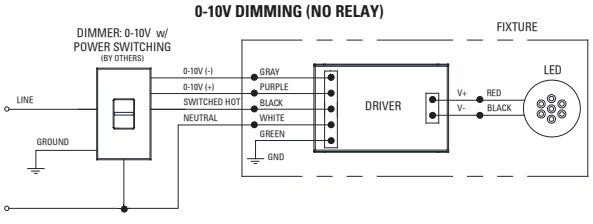
DIMMING DRIVER WIRING SCHEMES:

NOTES: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

D6 / DIML6
0-10V DIMMING W/RELAY TO SWITCH POWER



D6 / DIML6
0-10V DIMMING (NO RELAY)



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D7 / DIML7 and D7E

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

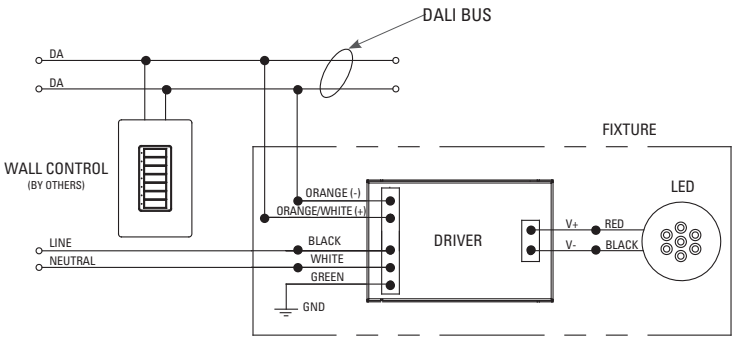
IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D7 / DIML7 and D7E Dimming Driver Wiring

D7 / DIML7 and D7E are linearly programmed dimming drivers.
D7 / DIML7 = EldoLED SOLOdrive DALI control dims from 100% to 0.1%
D7E = EldoLED ECOdrive DALI control dims from 100% to 1%

D7 / DIML7 / D7E
DALI CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D15 / DIML15

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

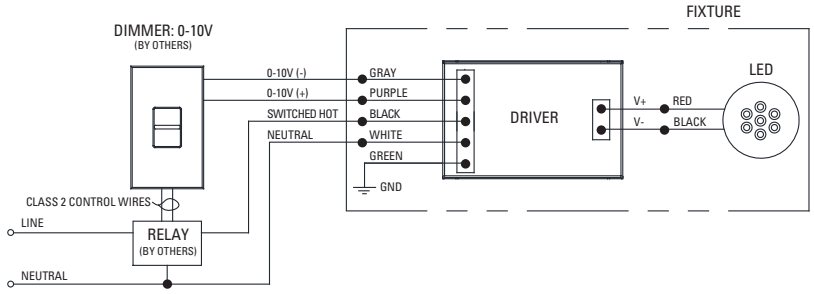
1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D15 / DIML15 LED: 0-10V, 347V Dimming Driver Wiring (Dims down to 1%) 347V Only

D15 / DIML15 Dimmer Compatibility Chart			
Manufacturer	Product	Dimmed Light Output Range	Qty Fixtures Per Dimmer*
347			Use source current per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
Acuity	Synergy ISD-BC	100% - 1%	
Douglas Lighting	WPN-5721, WPN-5822	100% - 1%	
Hubbell	Light Hawk2 LHD-IRS3-N347-xx	100% - 1%	
Leviton	Illumatech IP710-DLZ with 347V relay	100% - 1%	
Leviton	Centura Fluorescent Control System	100% - 1%	
Lutron	Nova NFTV-* dimmer plus 347V relay	100% - 1%	
Lutron	Diva DVTV-* dimmer plus 347V relay	100% - 1%	

* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D15 / DIML15
0-10V DIMMING W/RELAY TO SWITCH POWER



NOTE:
If switched, non-dimming operation is desired, cap off purple and gray wires individually at installation. Do NOT cap purple and gray wires together.

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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D18

DIMMING DRIVER WIRING SCHEMES:

NOTES:

Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D18 Dimming Driver Wiring

D18 are programmed dimming drivers.
D18 Moons DMX control dims from 100% to 1%

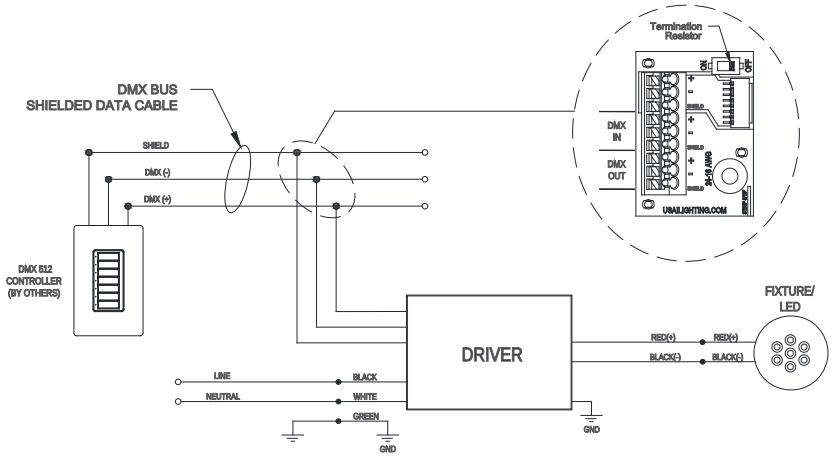
DMX BUS -
SHIELDED DATA CABLE

The data cable used must meet the following requirements:

- type: shielded, 2-conductor twisted pair
- maximum capacitance between conductors: 30 pF/ft
- maximum capacitance between conductor and shield: 55 pF/ft
- maximum resistance: 0.02 ohms/ft
- normal impedance: 100-140 ohms
- conductive core: 24 AWG is recommended

If 3-wire data cables are preferred, we suggest a Belden 9841 or equivalent cable which meets the specifications for EIA RS-485 applications. Do not use standard microphone cables: they cannot transmit DMX512 data reliably over long distances. NOTE: DMX link termination device, provided through Dip Switch on connection board, should be used on last fixture in line on a circuit to avoid signal loss.

D18
DMX CONTROLS



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I2-264-18 Revised 07/03/2018

DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D19 / DIML19

DIMMING DRIVER WIRING SCHEMES:

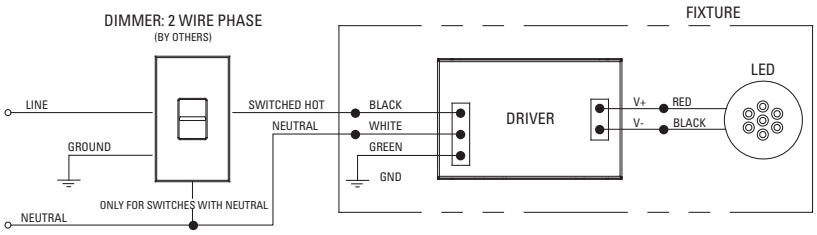
NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D19 / DIML19 LED: Hatch XTC series or equivalent - Forward and Reverse Phase Dimming Driver. Dims down to 1% contingent upon dimmer specification and load. 120V only.

D19 / DIML19
2 WIRE PHASE DIMMING



D19 / DIML19 Dimmer Compatibility Chart

120V ONLY		
Forward Phase / TRIAC Dimming		
Manufacturer	Product	Qty Fixtures Per Dimmer
Leviton	IPL06-10Z	Use fixture wattage per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
	6613-xxx	
Lutron	S-600P	
	S-603P	
	DV-600P	
	DV-603P	
	DVSC-603P	
	CT-600P	
	CT-603P	

120V ONLY		
Reverse Phase / ELV Dimming		
Manufacturer	Product	Qty Fixtures Per Dimmer
Leviton	6615	Use fixture wattage per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
	IPE04-xxx	
Lutron	NTELV-300	
	NTELV-600	
	SELV-300P	
	SELV-303P	
	DVELV-300P	
	DVELV-303P	

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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D22

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

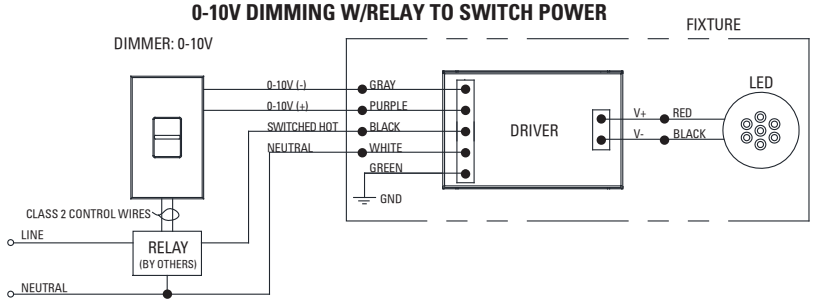
D22 LED: ERP ESS 0-10V Dimming Driver Wiring (Dims down to 1%)

D22 Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Dimmer*
120V / 277V				Use source current per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
Crestron	iLux dimmer expansion module	CLS-EXP-DIMFLV	100% - 1%	
Crestron	DIN Rail dimmer	DIN-4DIMFLV4	100% - 1%	
Crestron	DIN Rail analog output module	DIN-A08	100% - 1%	
Crestron	8 Channel dimmer module	GLX-DIMFLV8	100% - 1%	
Crestron	8 Channel dimmer module	GLXP-DIMFLV8	100% - 1%	
Leviton	IllumaTech dimmer	IP710-DLX	100% - 1%	
Lutron	Nova T	NFTV-XX	100% - 1%	
Lutron	Diva	DVTV-XX	100% - 1%	

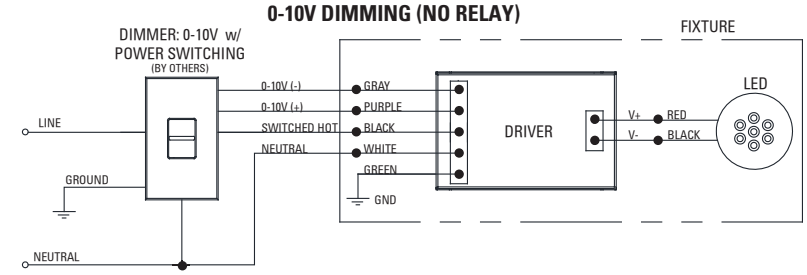
* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D22
0-10V DIMMING W/RELAY TO SWITCH POWER



NOTE:
If switched, non-dimming operation is desired, cap off purple and gray wires individually at installation. Do NOT cap purple and gray wires together.

D22
0-10V DIMMING (NO RELAY)



NOTE:
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I2-264-22 Revised 12/18/2019

DIMMING DRIVER WIRING SCHEMES:

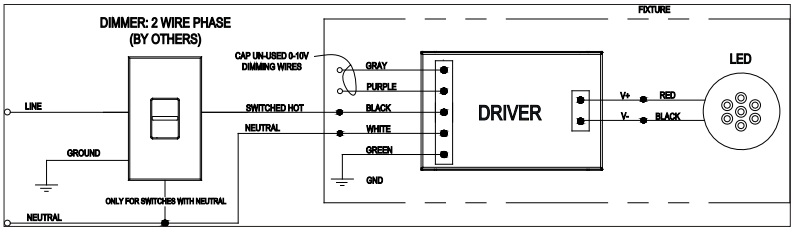
NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D22 LED: ERP ESS series or equivalent - Forward and Reverse Phase Dimming Driver.
Dims down to 1% contingent upon dimmer specification and load (see compatibility chart below). 120V only.

D22
2 WIRE PHASE DIMMING



D22 Dimmer Compatibility Chart

120V ONLY PHASE DIMMING				
Dimmer Information		Dimming Range		Qty Fixtures
Manufacturer	Product	Maximum	Minimum	Per Dimmer
Cooper	DAL06P	100%	0%	Use fixture wattage per fixture specification sheet to determine maximum number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating per dimmer specification sheet.
	DLC03P	100%	0%	
	SLC03P	100%	0%	
Leviton	6161	99%	10%	
	6631-2	100%	0%	
	6633-P	100%	0%	
	6673-10W	99%	6%	
	6683-IW	100%	2%	
	IPE04	100%	3%	
	IPI06-1LZ	99%	0%	
	VPE06	100%	5%	
Lightolier	ZP260QEW	99%	3%	
Lutron	CT103P	99%	6%	
	DV600P	99%	3%	
	DVCL-153P	99%	0%	
	DVELV303P	97%	3%	
	FAELV500	99%	7%	
	LG600P	99%	5%	
	MAELV600	99%	7%	
	S600P	99%	1%	
	S-603PG	86%	4%	
	SELV300P	97%	3%	
	TG-600P	99%	13%	
	TGCL-153P	99%	2%	

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COLOR SELECT®

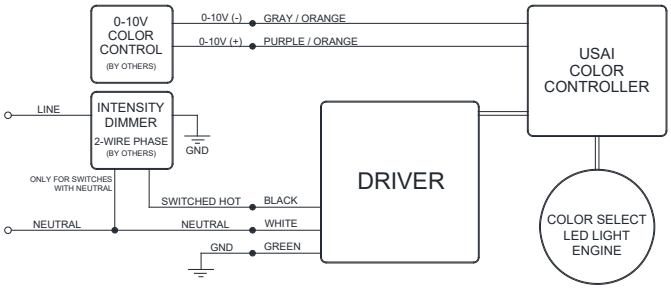
Covered By US Patents 8,581,520 and 8,456,109

INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML3

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML3 LED: Lutron Hi-Lume A-Series 2 Wire Fwd Phase (with neutral) / LED Dimming Driver Wiring (Dims down to 1%) 120V only.



D3 / DIML3 Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Dimmer* Fixture Wattage	
120V Only				39W and Less	40W - 80W
ETC	Sensor+ Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
ETC	Unison DRd Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
Lutron	Maestro Wireless® 600W dimmer	MRF2-6ND-120-	100% - 1%	1 – 8	1 – 4
Lutron	Maestro Wireless® 1000W dimmer	MRF2-10ND-120-	100% - 1%	1 – 13	1 – 6
Lutron	HomeWorks® QS adaptive dimmer	HQRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 600W dimmer	HQRD-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 1000 W dimmer	HQRD-10ND-	100% - 1%	1 – 13	1 – 6
Lutron	Caseta Wireless® Pro 1000W dimmer	PD-10NXD-	100% - 1%	1 – 13	1 – 6
Lutron	Stanza® dimmer	SZ-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 adaptive dimmer	RRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 1000 W dimmer	RRD-10ND-	100% - 1%	1 – 6	1 – 3
Lutron	myRoom DIN power module	MQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® QS wallbox power module	HQRJ-WPM-6D-120-	100% - 1%	1 – 26	1 – 13
Lutron	Homeworks® DIN power module	LQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® wallbox power module	HWI-WPM-6D-120	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® QS control unit	QSGR-, QSGRJ-	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® 3000 control unit	GRX-3100-, GRX-3500-	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4U module	HW-RPM-4U-120, LP-RPM-4U-120	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4A module	HW-RPM-4A-120, LP-RPM-4A-120	100% - 1%	1 – 26	1 – 13
Lutron	GP dimming panels	Various	100% - 1%	1 – 26	1 – 13
Lutron	Ariadni CL 250W dimmer	AYCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Diva CL 250W dimmer	DVCL-253P-, DVSCCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Grafik T CL or RF CL dimmer	GT-250M-, GTJ-250M-	100%-1%	1 – 8	1 – 4
Lutron	Nova T CL 250W dimmer	NTCL-250-	100%-1%	1 – 10	1 – 5

* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

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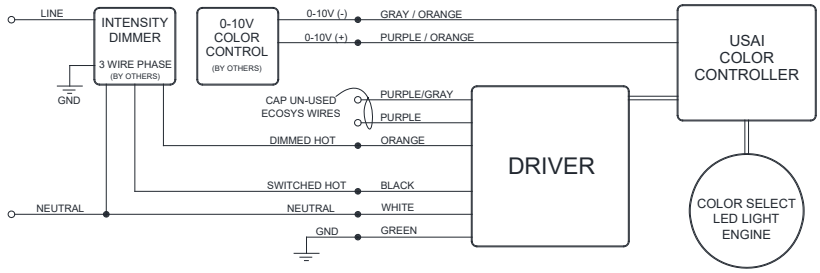
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML4

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML4 LED: Lutron Hi-Lume A-Series LED Driver with Eco System Control / LED Dimming Driver Wiring (Dims down to 1%)



D4 / DIML4 LED: Lutron Hi-Lume A-Series LED Driver with 3-Wire FL Control / LED Dimming Driver Wiring (Dims down to 1%)

D4 / DIML4 3-Wire Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V Only				39W and Less	40W - 80W
ETC	Sensor+ Cabinet	D20 Dimming module	100% - 1%	1–53	1–26
ETC	Unison DRd Cabinet	D20F Dimming module	100% - 1%	1–53	1–26
Lutron	Nova T	NTF-10-	100%–1%	1–41	1 – 20
Lutron	Nova T	NTF-103P-	100%–1%	1–20	1 – 10
Lutron	Nova	NF-10-	100%–1%	1–41	1 – 20
Lutron	Nova	NF-103P-	100%–1%	1–20	1 – 10
Lutron	Vareo	VF-10-	100%–1%	1–20	1 – 10
Lutron	Skylark	SF-10P-, SF-103P-	100%–1%	1–20	1 – 10
Lutron	Diva	DVF-103P-, DVSCF-103P-	100%–1%	1–20	1 – 10
Lutron	Ariadni	AYF-103P-	100%–1%	1–20	1 – 10
Lutron	Vierti	VTF-6A-	100%–1%	1–15	1 – 7
Lutron	Maestro	MAF-6AM-, MSCF-6AM-	100%–1%	1–15	1 – 7
Lutron	Maestro Wireless	MRF2-F6AN-DV-	100%–1%	1–15	1 – 7
Lutron	RadioRA 2	RRD-F6AN-DV-	100%–1%	1–15	1 – 7
Lutron	HomeWorks QS	HQRD-F6AN-DV	100%–1%	1–15	1 – 7
Lutron	Interfaces	PHPM-3F-120, PHPM-3F-DV	100%–1%	1–41	1 – 20
Lutron	GP Dimming Panels	Various	100%–1%	1–41	1 – 20
277V Only				40W and Less	41W - 80W
ETC	Sensor+ Cabinet	D20 Dimming module	100% - 1%	1–53	1–26
ETC	Unison DRd Cabinet	D20F Dimming module	100% - 1%	1–53	1–26
Lutron	Nova T	NTF-10-277-	100%–1%	1–44	1 – 22
Lutron	Nova T	NTF-103P-277-	100%–1%	1–33	1 – 16
Lutron	Nova	NF-10-277-	100%–1%	1–44	1 – 22
Lutron	Nova	NF-103P-277-	100%–1%	1–33	1 – 16
Lutron	Skylark	SF-12P-277-, SF-12P-277-3	100%–1%	1–33	1 – 16
Lutron	Diva	DVF-103P-277-, DVSCF-103P-277-	100%–1%	1–33	1 – 16
Lutron	Ariadni	AYF-103P-277-	100%–1%	1–44	1 – 22
Lutron	Vierti	VTF-6A-	100%–1%	1–33	1 – 16
Lutron	Maestro	MAF-6AM-277-, MSCF-6AM-277-	100%–1%	1–20	1 – 10
Lutron	Maestro Wireless	MRF2-F6AN-DV-	100%–1%	1–33	1 – 16
Lutron	RadioRA 2	RRD-F6AN-DV-	100%–1%	1–33	1 – 16
Lutron	HomeWorks QS	HQRD-F6AN-DV	100%–1%	1–33	1 – 16
Lutron	Interfaces	PHPM-3F-DV	100%–1%	1–88	1 – 44
Lutron	GP Dimming Panels	Various	100%–1%	1–88	1 – 44

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

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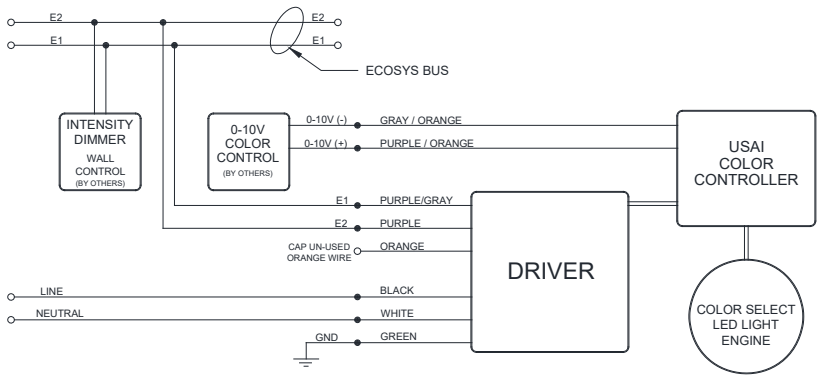
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML4 Continued

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML4 LED: Lutron Hi-Lume A-Series LED Driver with Eco System Control / LED Dimming Driver Wiring (Dims down to 1%)



D4 / DIML4 LED: Lutron Hi-Lume A-Series LED Driver with EcoSystem Control / LED Dimming Driver Wiring (Dims down to

D4 / DIML4 EcoSystem Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V / 277V				39W and Less	40W - 80W
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	100%–1%	1–32	1–16
Lutron	Energi Savr Node	QSN-1ECO-S, QSN-2ECO-S	100%–1%	1–64	1–32
Lutron	GRAFIK Eye QS (120V ONLY)	QSGRJ- E, QSGR- E	100%–1%	1–64	1–32
Lutron	Quantum	Various	100%–1%	1–64	1–32

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

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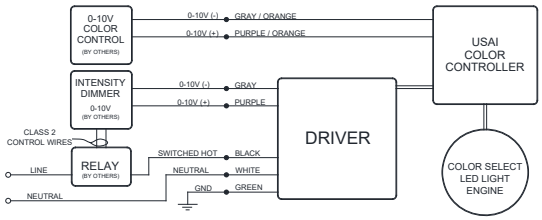
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML6A & 6B
DIML6E & DIML6F

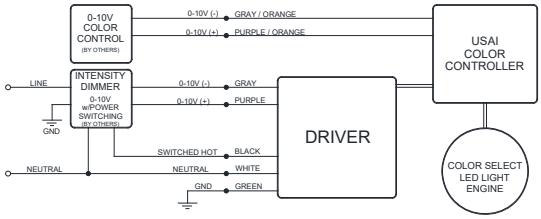
INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

0-10V Dimming w/ Relay Switch to Power



0-10V Dimming



D6A / DIML6A and D6E / DIML6E LED Dimming Compatibility Table

D6A / DIML6A and D6E / DIML6E are linearly programmed dimming drivers for use with the dimming controls listed in the table below
D6A / DIML6A = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1%
D6E / DIML6E = EldoLED ECOdrive 0-10V control dims from 100% to 1%

D6A / DIML6A and D6E / DIML6E Dimmer Compatibility Chart					
Manufacturer	Product	Part Number	Dimmed Light Output Range		Qty Fixtures Per Dimmer*
120V & 277V			DIML6A	6E	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Lutron	Diva	DVTV/NFTV with PP-20	99% -	0.1% 1%	
Lutron	Nova T	NTFTV with PP-20	99% -	0.1% 1%	
Lutron	Energi Savr Node	QSN-4T16-S	100% -	0.1% 1%	
Lutron	GP Dimming Panels	TVM2 Module	99% -	0.1% 1%	
Lutron	Interfaces	GRX-TVI w/ GRX3503	100% -	0.1% 1%	
Sensor Switch	nIO	nIO EZ	100% -	0.1% 1%	
enlighted	Control Unit	CU-3E-1R	100% -	0.1% 1%	

D6B / DIML6B and D6F / DIML6F LED Dimming Compatibility Table

D6B / DIML6B and D6F / DIML6F are logarithmic-programmed dimming drivers for use with the dimming controls listed in the table below
D6B / DIML6B = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1% D6F / DIML6F = EldoLED ECOdrive 0-10V control dims from 100% to 1%

D6B / DIML6B and D6F / DIML6F Dimmer Compatibility Chart					
Manufacturer	Product	Part Number	Dimmed Light Output Range		Qty Fixtures Per Dimmer*
120V & 277V			DIML6B	6F	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Bush-Jaeger	Electronic potentiometer	2112U-101	100% -	0.1% 1%	
Jung	Electronic potentiometer	240-10	100% -	0.1% 1%	
Leviton	Illuma Tech dimmer	IP710-DLX	100% -	0.1% 1%	
Lightolier (Philips)	Momentum (120V ONLY)	ZP600FAM120	100% -	0.1% 1%	
Merten	Electronic potentiometer	5729	100% -	0.1% 1%	
Pass & Seymour	Titan	CD4FB-W	100% -	0.1% 1%	
Watt Stopper	Miro	DCLV1	100% -	0.1% 1%	
Synergy	Wallbox Dimmers	ISD BC	100% -	0.1% 1%	
ABB	i-bus	SD/S 2.16.1	100% -	0.1% 1%	
Crestron	Modules	GLX-DIMFLV8, GLXP-DIMFLV8	100% -	0.1% 1%	
Crestron	Green Light	GLPAC-DIMFLV4-, GLPAC-DIMFLV8-	100% -	0.1% 1%	
Crestron	Green Light Power Pack	GLPP-DIMFLVEX-PM, GLPP-1DIMFLV2EX-PM, GLPP-1DIMFLV3EX-PM	100% -	0.1% 1%	
Crestron	DIN Rail Analog Output Module	DIN-A08	100% -	0.1% 1%	
Crestron	DIN Rail 0-10V Fluorescent Dimmer	DIN-4DIMFLV4	100% -	0.1% 1%	
Crestron	iLux 0-10V Dimmer Expansion Module	CLS-EXP-DIMFLV	100% -	0.1% 1%	
enlighted	Control Unit	CU-3E-1R	100% -	0.1% 1%	

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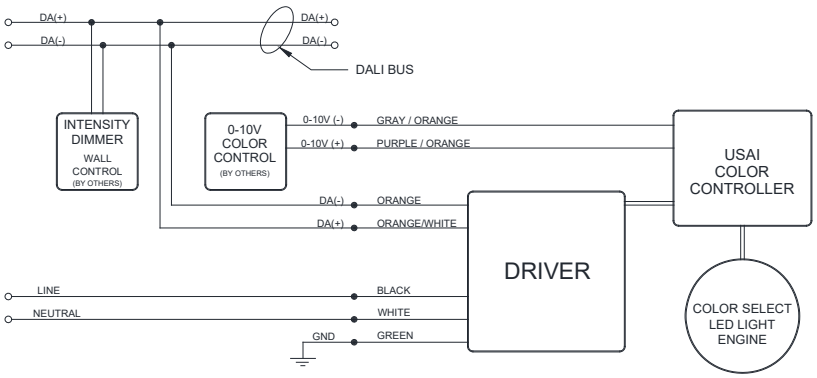
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML7

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML7 LED: eldoLED DALI dimming driver (dims down to 0.1%)



NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

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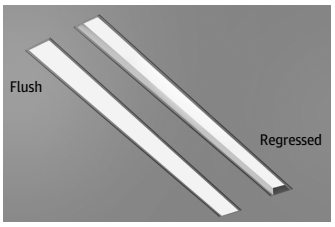
MARK ARCHITECTURAL LIGHTING™

Slot 4 LED
Recessed Linear



Slot 4 LED takes both form and function a step further with increased efficacy and integral controls creating a digitally addressable luminaire that is perfect where visually harmonious illumination and energy efficiency are desired.

Slot 4 LED is the ideal choice for spaces that emphasize lines and clean contemporary design. It is a perfect fit for Armstrong TechZone™ ceiling systems. A regressed lens option provides added dimension to the sleek, slender design and the flush lens now has a Wet Label option.

Type:

Project:

Catalog Number:

DO NOT TYPE HERE. Autopopulated field.

Specification Features (continued on page 2)

Housing
Nominal 4" x 2', 3', 4', 5', 6', 7', 8' and continuous rows in 1" increments as standard, upper housing fabricated from cold-rolled steel with extruded aluminum ceiling trim.

Finish
Painted high reflectance matte white powder coat.

Reflector
Precision-formed steel; high reflectance matte white powder coat; 93% reflectivity.

Shielding
Flush Lens: Snap-in 90% transmissive satin acrylic lens.

Regressed Lens: Lay-in 90% transmissive satin acrylic lens.

Mounting
Recessed. Available for sheetrock, 9/16" slot grid or 15/16" inverted tee ceilings, or 9/16" inverted tee.

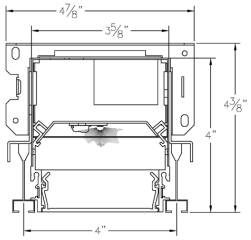
Fixture Performance - SL4L*

Lumens Output	400 LMF		600 LMF**		800 LMF**		1000LMF	
Fixture Style	RLP	FLP	RLP	FLP	RLP	FLP	RLP	FLP
Delivered Lumens/FT	316	314	544	541	737	734	928	924
Input Watts/FT	4	4	6	6	8	8	10	10
Lumen/Watt	91	91	95	95	93	93	90	89

*CCT (35K)
*Consult factory for customized lumen output and wattage
**Based on calculated values

A+ Capable options indicated by this color background.

Technical Drawing



Flush - (FLP)

Ordering

Example: SL4L LOP 4FT FLP TG 90CRI 35K 400LMF S80CRI S27K E10WLCP NLIGHT WL USPOM

Series
- SL4L — Slot 4 LED Linear Recessed

Linear Length Plan
- LOP — Linear Optimized Plan

Total Run Length
- 2FT 2′
- 3FT 3′
- 4FT 4′
- 5FT 5′
- 6FT 6′
- 7FT 7′
- 8FT 8′
- _FT_ *Specify continuous linear feet in 1" increments (7FT6 = 7FT 6IN)

Fixture Style
- RLP[1] Regressed Lens
- FLP[2,3] Flush Lens

Ceiling Trim
- FL[4] 5/8" Flange(sheetrock)
- TG 9/16" or 15/16" Flat or Inverted Tee
- GB[4] Trimless (sheetrock)
- WFL Perimeter Mount, 5/8" Flange (Sheetrock)
- WTG 9/16" Flat or Inverted Tee, Perimeter Mount

Direct Light Source Color Rendering
- 80CRI 80 CRI
- 90CRI 90 CRI

Direct LED Color Temp
- 27K* 2700K
- 30K 3000K
- 35K 3500K
- 40K 4000K
- 50K* 5000K

Direct LED Light Output
- 400LMF 400 Lumens per FT
- 600LMF 600 Lumens per FT
- 800LMF 800 Lumens per FT
- 1000LMF 1000 Lumens per FT
- _LMF* [11] ## Lumens per FT (Limited to 300LMF to 1000LMF in 50LMF increments)

Direct Distribution
- (blank) Standard Distribution
- WW[5] Wall Wash

Downlight [11]
- 2DL[6,7] LED Downlight Standard
- _DL[6,7] LED downlights per Run (3DL, 4DL, ect.)

Downlight Color Rendering
- S80CRI 80 CRI
- S90CRI 90 CRI

Downlight Color Temp
- S27K 2700K
- S30K 3000K
- S35K 3500K
- S40K 4000K

Minimum Dimming Level
- NODIM Non - Dim
- MIN1 Constant current, dimming to 1%
- DARK Constant current, dimming to 0.1%
- MIN5[8] Constant current, dimming to 5%
- MIN10[18] Constant current, dimming to 10%

Voltage
- 120 120V
- 277 277V
- 347[9,11] 347V

Finish
- (blank) White
- xxx/BLKT Black, textured
- xxx/SLVT Silver, textured
- xxx/RALTBD RAL paint finish

xxx = fill in with the appropriate ceiling trim. Only trims are painted

Emergency Options
- (blank) No Emergency
- E10WLCP[10,19] 4ft Emergency Section with battery pack
- __E10WLCP[10,19] Number of 4ft Emergency Section(s) with battery pack
- _EC[12] # of Emergency Circuits

Control Input
- (blank) Non-dim [13]
- ZT 0 10V
- NLIGHT nLight enabled
- NLTAIR2[20] nLight Air (wireless enabled)
- ECOD* [17] Lutron Hi-Lume digital driver
- ECOD2* [16,17] Lutron Hi-Lume 2-wire (1% dimming)
- ECOD5* Lutron 5-series digital driver (5% dimming)
- DALI[22] DALI compatible

Primary Sensor [14]
- (blank) No Sensor
- PDT Occupancy Sensor- Dual Technology (Passive Infrared & Microphonics)
- ADC Daylight dimming sensor
- API PIR Occupancy Sensor & Photocell
- APD PDT Occupancy Sensor & Photocell

Options
- CP[21] Chicago Plenum
- USPOM US point of assembly
- WL[3,7,15,19] Wet Location Listing
- DPL Damp Location Listing
- PWS 6' pre-wire, 3/8" diameter, 18 gauge

* Requires longer lead time.

See Notes next page.

Specification Features (continued)

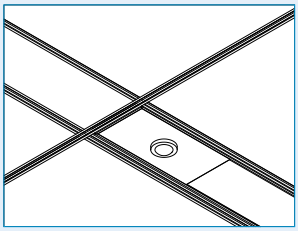
LED Components
Linear: Nichia® - 757 Series LED chips (available in 80 or 90 CRI)

LED Life
Rated 65,000 hours (L80) at 25 °C ambient temperature.

Color Consistency
The Acuity Brands circuit boards for the linear LED components use a precise binning algorithm which creates a consistent color temperature from board to board. Color variation is no greater than a 2.5 Step MacAdam (2.5SDCM) along the black body locus from board to board.

Driver
eldoLED constant current driver options delivers ultra-smooth dimming resolution from 100% to 0.1%, while assuring flicker free, low current inrush, 89% efficiency and low EMI.

Integrated Controls
Optional nLight® embedded controls make luminaire addressable-allowing it to digitally communicate with other nLight enabled controls such as dimmers, switches, occupancy sensors and photocontrols. Simply connect all the nLight enabled control devices using standard CAT5 Cabling. (Input option: NLIGHT)



Occupancy Sensor (PDT) and/or Photocell (ADC)

A+ Capable Luminaire
This item is an A+ capable luminaire, which has been designed and tested to provide consistent color appearance and out-of-the-box control compatibility with simple commissioning.

- All configurations of this luminaire meet the Acuity Brands' specification for chromatic consistency
- This luminaire is part of an A+ Certified solution for nLight® control networks when ordered with drivers marked by a shaded background*
- This luminaire is part of an A+ Certified solution for nLight control networks, providing advanced control functionality at the luminaire level, when selection includes driver and control options marked by a shaded background*

To learn more about A+, visit www.acuitybrands.com/aplus.

*See ordering tree for details

Notes
1. Supplied with lift and shift lay-in lens.
2. Supplied with snap-in lens.
3. Wet Location Label available with Flush Lens only
4. Not intended for post sheetrock installation.
5. Wall Wash not available with downlights or RLP lens option.
6. See notes on page 3, downlights only available with DARK dimming level.
7. Wet Location label not available with downlights, regressed lens, or with Primary Sensor options, or PSW.
8. ECOD5 must select MIN5.
9. Not available with 2ft fixture sections or with E10WLCP, NLIGHT, sensors, or ECO options. Must select MIN1 option.
10. Remote mounted, not available with CP option.
11. Not available with ECOD, ECOD2, ECOD5.
12. Standard 4' EC section, defaults to end of run. 2ft, 3ft and 5ft powers entire fixture, 6ft powers 3ft EC section.
13. Only available with NODIM option.
14. Sensors not available with WW, NODIM driver, WL or RLP option. Default location for sensor is the left side of the fixture, for runs the first fixture will include the sensor.
15. Cannot be installed in vertical surfaces.
16. Must use 120 volt.
17. Must select MIN1 options, not available with sensors.
18. MIN10 not available with 347, sensors, NLIGHT or NLTAIR2, requires ZT.
19. Battery kit is not wet listed. Can be used with WL unit if installed in a dry location.
20. Must select MIN1 or DARK. Not available with RLP, WW, PDT, ADC or 347, DPL or WL. If with EC, cannot be on individual units, and on runs, the EC cannot be on the same section as NLTAIR2.
21. CP not available with NLTAIR2.
22. DALI is only available with DARK or MIN1. It is not available with sensors or downlights.

Certification
CSA tested to UL 1598 standards. Optional Damp or Wet location listings available, see ordering tree.

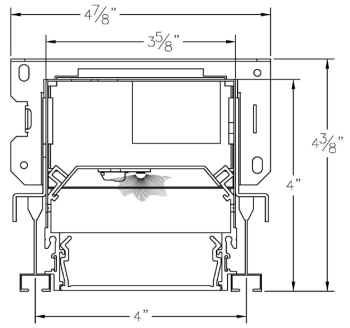
Listings
DesignLights Consortium® (DLC) qualified product. Not all versions of this product may be DLC qualified. Please check the DLC Qualified Products List at www.designlights.org/QPL to confirm which versions are qualified.

Warranty
5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/CustomerResources/Terms_and_conditions.aspx

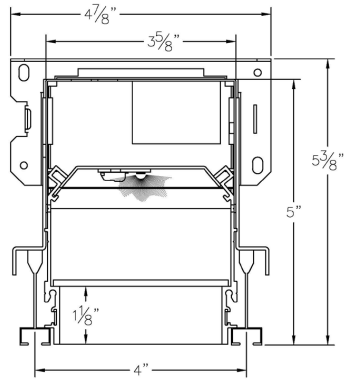
Note: *Actual performance may differ as a result of end-user environment and application.*
All values are design or typical values, measured under laboratory conditions at 25 °C.
Specifications subject to change without notice.

Photometry
For photometric information refer to www.marklighting.com.

Technical Drawing

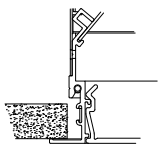


Flush - (FLP)

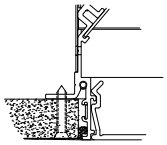


Regressed - (RLP)

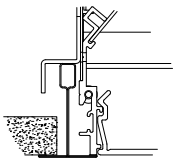
Ceiling Trim



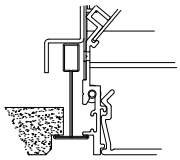
FL
(Flanged sheetrock)



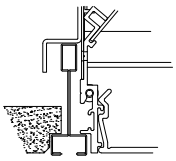
GB
(Flangeless sheetrock)



TG
(15/16" Grid)



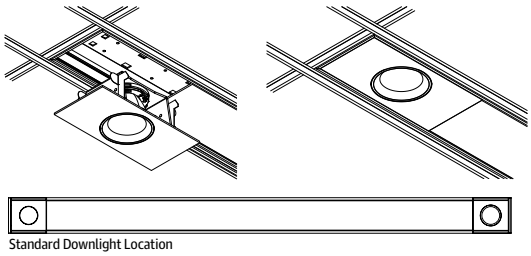
TG
(9/16" Grid)



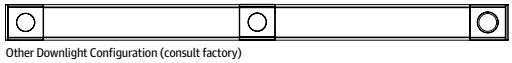
TG
(9/16" Slot Grid)

Downlights

Optional downlights powered by Xicato Spot Modules are available with any linear length and no less than 2' on center spacing. Each downlight module is 6W with 700 lumens delivered (28 degree beam spread). Downlights are supplied with a dedicated feed-point and will be controlled separately.



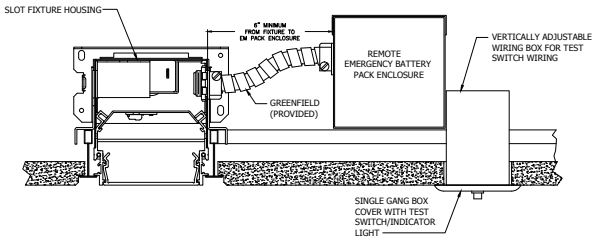
Standard Downlight Location



Other Downlight Configuration (consult factory)

Notes
- 2DL - Downlights are supplied at each end of an individual unit
- __DL - Multiple downlights will be supplied with one at each end and the remainder will be centered over the length of the run.
- Downlights are not adjustable and are provided with solite lens

Remote Emergency Battery Mounting

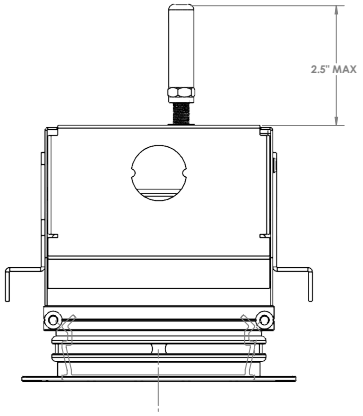


Notes
- Delivers 700 lumens per 4FT length. Default location is the right side of fixture and end of run.
- Provided with 4FT of flexible conduit. Maximum of 25FT remote distance if extended. Extension provided by others.

nLight Air Wireless

nLight Air is now available integrated into the luminaire.

The default location of the antenna will be at the left end of an individual unit. On a run, it will be placed at the beginning or left end of the first section. Please consult factory for other placement options.

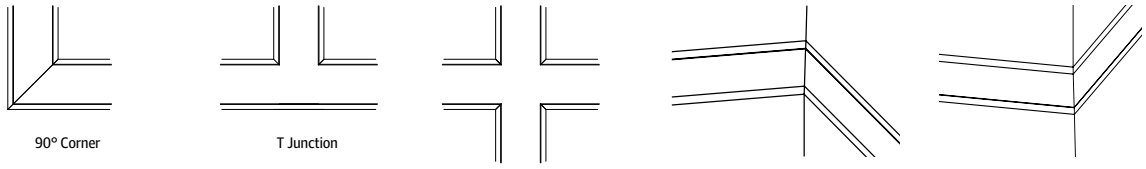


Continuous Runs

Slot 4 LED continuous rows can be configured in 1" increments.

Run Patterns, Corners and Junction

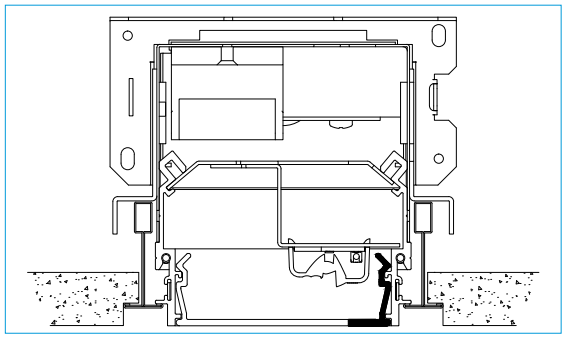
Slot 4 LED patterns be configured in 1' increments with illuminated 90° inside and outside corners, T junctions, and X junctions with standard 2' corner and junction lengths. For custom angles, corner or junction lengths, consult factory.

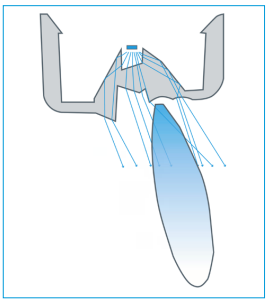


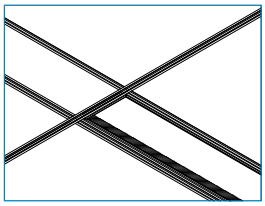
Layout Sketch

Please draw and configure your linear run below.

Optics
Slot LED's patent-pending, precision lumen DIRECTIR optics condition and refract light to deliver accurately controlled, striation-free, and uniform white light. All lumen DIRECTIR optics are injection-molded, optical grade, UV-resistant acrylic with selective finishing/polishing treatment.

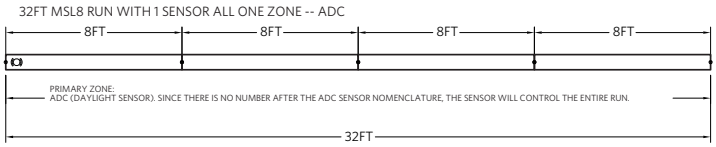






Wall Wash (WW)

INTEGRATED SENSOR LAYOUT



Notes:
- Only one sensor per zone

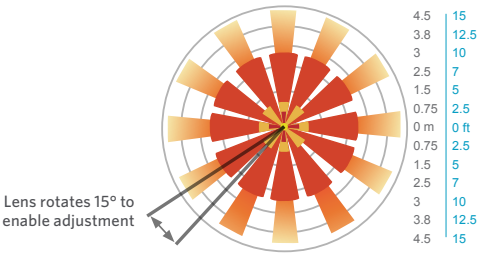
OCCUPANCY DETECTION COVERAGE

At the 7.5 ft (2.9 m) hanging height of a typical pendant mount fixture the sensor provides 10 ft (3.05 m) radial detection of small motion. At a 9 ft (2.74 m) hanging height the radius is 12 ft (3.66 m) for small motion.

Adequate for walking motion detection from mounting heights between 7.5 ft (2.29 m) and 20 ft (6.10 m).

Initial detection will occur earlier when walking across sensor's field of view than when walking directly at sensor.

Initial detection of walking motion into long coverage segment will occur at distances of 2x the mounting height up to 15 ft (4.57 m) and 1.75x up to 20 ft (6.10 m). Lens assembly rotates 15° to enable adjustment in order to line up long segments.

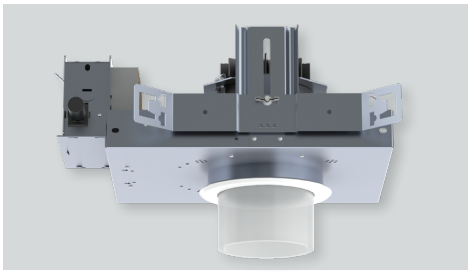


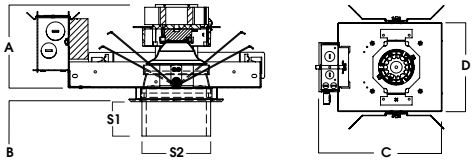
illumitech decorative

4" ROUND DOWNLIGHT / NON-IC

ILLUMITECH DECORATIVE / 4000 LUMENS

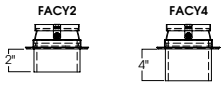
recessed fixtures





A	B	C	D
10L-20L: 4.9 30L-40L: 5.7	0.625 15.2 mm	13.2 335.3 mm	9.5 241.3 mm

TRIM	S1	S2	CUT OUT
FACY2	2.0	4.0	4.7
FACY4	4.0	4.0	119.4 mm



RDFO4XT - DECORATIVE TRIM / NON-IC RATED

APPLICATION

Illumitech decorative recessed series offer two lengths of decorative acrylic cylinder (FACY). Cylinder glows softly to create ambiance.

FEATURES

Two-stage optical system with regressed Solite lens for smooth light distribution. Quick change LED module with interchangeable optics for job site adjustment and fixture maintenance. Shallow plenum design. Tool-less driver and j-box access. Posi-lock trim retention torsion springs.

TRIM FINISH

Decorative cylinder is soft etched UV stabilized cast machined acrylic. Matte White flange is standard.

ELECTRONICS

LED system features Xicato LED module with proprietary phosphor technology that provides consistent, stable color with CCT control of +/- 100K over life of the light engine. Base CRI is 83 with 2-step MacAdam Ellipse binning. High CRI is 98 with 1x2-step MacAdam Ellipse binning. Variety of electronic 120V/277V and dimming drivers.

CONSTRUCTION

Housing/frame constructed of #20 ga. galvanized steel to resist corrosion. Self-Flanged one piece trim spun from 0.063" thick high purity aluminum and finished to specification.

CODE COMPLIANCE

BAA Compliant. ETL certified to meet US and Canadian standards. Suitable for dry or damp locations. Manufactured and tested to UL standards No. 1598/8750.

WATTAGE TO LUMENS UPDATE					
CURRENT PART NUMBER EXAMPLE	PREVIOUS PART NUMBER EXAMPLE	SOURCE LUMENS[1]	DELIVERED LUMENS[2]	SYSTEM WATTS	LPW
RDFO4XT10L	RDFO4LEDXI15W	1000	554	11.1	49.9
RDFO4XT13L	RDFO4LEDXI20W	1300	746	15.0	49.7
RDFO4XT20L	RDFO4LEDXI33W	2000	1148	23.7	48.4
RDFO4XT30L	RDFO4LEDXI52W	3000	1722	34.6	49.8
RDFO4XT40L	N/A	4000	2210	39.9	55.4

SERIES	LUMENS[1]		CCT		OPTICS		DRIVER / VOLTAGE[4]				OPTIONS[5]	
RDFO4XT	83 CRI				XN[3]	10°	E_	Electronic Driver	1	120V	BH27[6]	27" Solid Bars
	10L	1000 Lm	27K	2700K	ND	27°	DS10_	10% 0-10V	2	277V	H12	12" - 24" Expandable Bars
	13L	1300 Lm	30K	3000K	MD	40°	DO10_	1% 0-10V			H06	6" - 12" Expandable Bars
	20L	2000 Lm	35K	3500K	WD	45°	DS2W1	1%, ELV/MLV, 120V			CB24	24" C-Channel Bars
	30L	3000 Lm	40K	4000K	XW	50°	DLTE1	1% Lutron® 2-Wire Forward Phase, 120V			EM	EM Battery Pack
	40L	4000 Lm					DL3E_	1% Lutron® EcoSystem®, Fade			FS	Fusing
	98 CRI						EL10_	1%, eldoLED			EB	Black Housing
	10L	1000 Lm	27HK	2700K			ED01_	0.1%, eldoLED			CR	Corrosion Resistant
	13L	1300 Lm	30HK	3000K			DALI_	DALI Control			PR[7]	Deep Ceiling Extension
	20L	2000 Lm	35HK	3500K							GR	Goof Ring
	30L	3000 Lm	40HK	4000K							AMB	Anti Microbial Finish

TRIM	COLOR		CAST ACRYLIC		TRIM OPTIONS	
RD4FXTMWSO[8]	FA	Frosted Clear	CY2	2" Deep Acrylic	GS	Gasket
			CY4	4" Deep Acrylic	WL	Wet Location

EXAMPLE: RDFO4XT13L35KMDE1H12/RD4FXTMWSOFACY4

NOTES:
1 Nominal Source Lumens at Any CCT **2** Nominal Delivered Lumens 83CRI at Any CCT with MD-FACY4 **3** 10L-20L 83 and 98CRI **4** Contact Factory for Additional Options **5** See Product Options Page for Details
6 Standard Bar Hangers **7** Contact Factory **8** "F" Indicates Self-Flange Trim, Matte White Standard

SPECTRUM LIGHTING INC.

PROJECT:

TYPE:

Dimensions and values shown are nominal. Spectrum Lighting continually works to improve products and reserves the right to make changes which may alter the performance or appearance of products.

WWW.SPECLIGHT.COM • 994 JEFFERSON STREET, FALL RIVER, MA 02721 • 508.678.2303 FAX 508.678.2260

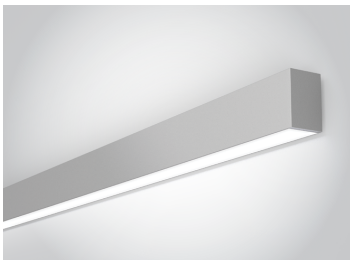
CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

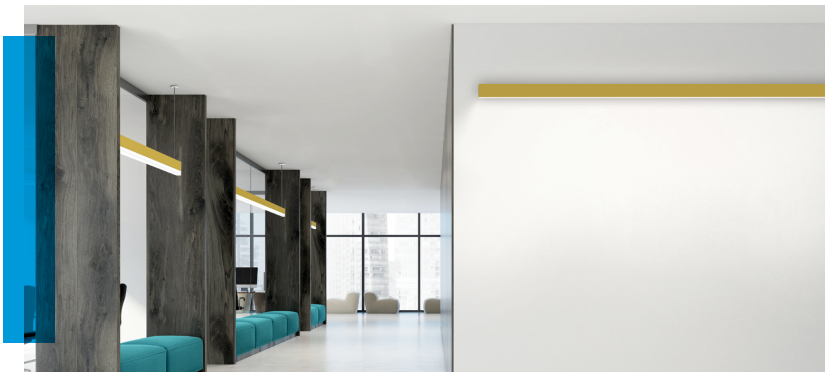
MARK ARCHITECTURAL LIGHTING

SPECIFICATIONS

TYPE:

PROJECT:





SLOT 1

DIRECT WALL

HIGHLIGHTS

- 200 to 1000 lumens per foot
- Up to 117 Lumens per Watt
- Three distributions: Lambertian, Wall Wash or Wall Graze
- Multiple lens treatment options include drop and edge view
- Shielding provided by integrated deep cell quiet ceiling baffle
- Flicker free dimming to dark (0.01%) enabled by Modulus power and control architecture with integrated digital nLight® module for system networking
- Total System Integration features 5-year limited warranty by Acuity Brands, covers all components and construction

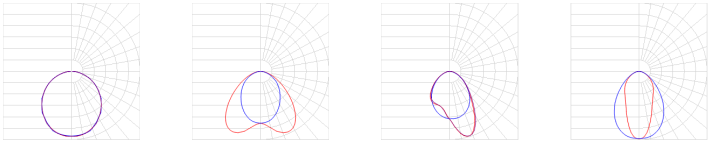
FIXTURE PERFORMANCE

Nominal Lumens/Foot	200LMF	400LMF	600LMF	800LMF	1000LMF
Delivered Lumens/Foot	240	370	550	750	935
Input Watts/Foot	2.06	3.27	5.08	7.27	9.45
Lumens/Watt	117	113	108	103	99

**Based on a 4ft 35K fixture with standard lambertian distribution*

nLIGHT eldoLED

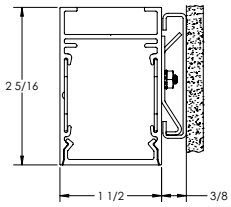
DIRECT DISTRIBUTION



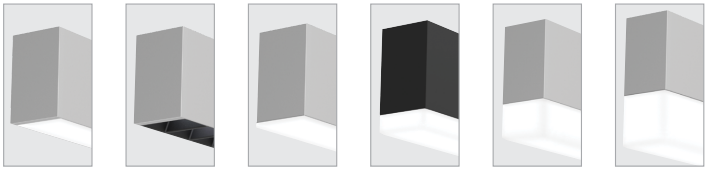
Flat Lens (no optic) | Batwing (BW) | Wall Wash (WW) | Wall Graze (WG)

DIMENSIONS

Section View



DIFFUSERS/SHIELDING



Flat Lens | Quiet Ceiling Baffle | Edge View Lens | 1/2" Drop Lens | 1" Drop Lens | 1-1/2" Drop Lens

AcuityBrands

ORDERING

Example: S1LWD LLP 32FT MSL8 90CRI 30K 600LMF MIN1 SCT MVOLT WHT ZT

Series

S1LWD	Slot 1 Wall - Direct

Plan

LCB	Linear center balanced
LLP	Linear longest possible
LSL	Longest same length

Total Run Length

_FT	Specify continuous run length (in whole feet, 2' minimum)

Unit length may affect available options. 2' & 3' only available as individual units

For runs longer than 8FT: ALWAYS order the run by the TOTAL RUN LENGTH. Ordering the sections individually will not provide the correct joining hardware to allow connection in the field.

Max Section Length

MSL2	2'
MSL3	3'
MSL4	4'
MSL5	5'
MSL6	6'
MSL7	7'
MSL8	8'

Direct Light Source Color Rendering

90CRI	90 CRI

Direct LED Color Temp

27K	2700K
30K	3000K
35K	3500K
40K	4000K
50K	5000K

Direct LED Light Output

200LMF	200 lumens per FT
400LMF	400 lumens per FT
600LMF	600 lumens per FT
800LMF	800 lumens per FT
1000LMF	1000 lumens per FT
_LMF	# lumens per FT

Limited to 200LMF - 1000LMF in 50LMF increments

Direct Distribution (Optics)

(blank)	Standard lambertian distribution
WW	Wallwash distributions
WG	Wall graze distribution
DBW	Direct Batwing distribution

Minimum Dimming Level

MIN1	Constant current, dimming to 1%
DARK	Constant current, dimming to 0.1%

Direct Shielding

(blank)	Flush lens
QCBFW	Quiet ceiling baffle, white
QCBFB	Quiet ceiling baffle, black
DRP05	1/2" Drop lens
DRP1	1" Drop lens
DRP15	1 1/2" Drop lens
EGLD	Edge View direct lens

No shielding options available with optics

Voltage

MVOLT	Multi-volt, 120-277
120	120V
277	277V
347	347V

347V is not available with E35INV, EC, WEC, GTD.

Finish

WHT	White (gloss)
BLK	Black (gloss)
SLV	Silver (gloss)
WHTT	White (textured)
BLKT	Black (textured)
SLVT	Silver (textured)
RALTBD	RAL paint finishes

Emergency Options

(blank)	No emergency option
E35INV	35W Micro inverter
WEC	Emergency circuit for entire run
_EC	# of emergency circuits
GTD	Generator transfer device

MVOLT is not available with E35INV & GTD.

Control Input

ZT	0-10V control
NLIGHT	nLight enabled
NLTAIR2	nLight AIR (wireless) enabled
DALI	DALI compatible

ZT is only available with 2 zones.

Primary Zone

(blank)	Select if single zone
NS_	Select if multi-zones required (with no sensors), call out length of zone in feet. Zones cannot end mid-fixture.

Not available with NLTAIR2

Secondary Zone

(blank)	Select if single zone
SNS_	Select if secondary zone is required (with no sensors), call out length of zone in feet. Zones cannot end mid-fixture.

Not available with NLTAIR2

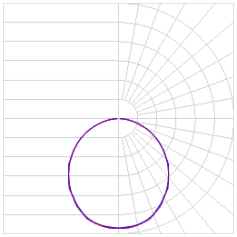
Tertiary Zone

(blank)	Select if single zone
TNS_	Select if tertiary zone is required (with no sensors), call out length of zone in feet. Zones cannot end mid-fixture.

Not available with NLTAIR2

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

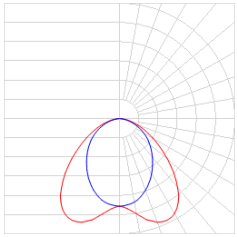
PHOTOMETRICS



(Lumens Per Zone)

Lambertian
Test Report: ISF 201609P73
IES LM79-08
S1LWD 4FT 90CRI 35K 1000LMF
Lumens: 3732.4
Wattage: 37.82
Efficacy: 98.69

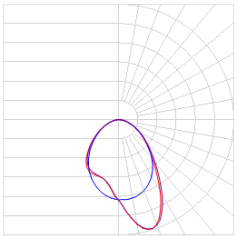
Zonal Lumen Summary		
Zone	Lumens	% Luminaire
0-10	126.1	3.4%
10-20	361.4	9.7%
20-30	541.4	14.5%
30-40	643	17.2%
40-50	657.1	17.6%
50-60	589.1	15.8%
60-70	454.2	12.2%
70-80	270.3	7.2%
80-90	89.7	2.4%



(Lumens Per Zone)

Batwing
Test Report: ISF 201590P73
IES LM79-08
S1LWD 4FT 90CRI 35K 1000LMF DBW
Lumens: 2992
Wattage: 37.82
Efficacy: 79.11

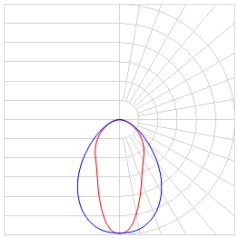
Zonal Lumen Summary		
Zone	Lumens	% Luminaire
0-10	98.1	3.3%
10-20	303.9	10.2%
20-30	494.9	16.5%
30-40	599.7	20.0%
40-50	570	19.0%
50-60	444.8	14.9%
60-70	291.6	9.7%
70-80	14.8	5.0%
80-90	40.3	1.3%



(Lumens Per Zone)

Wall Wash
Test Report: ISF 201614P73
IES LM79-08
S1LWD 4FT 90CRI 35K 1000LMF WW
Lumens: 3362.3
Wattage: 37.82
Efficacy: 88.90

Zonal Lumen Summary		
Zone	Lumens	% Luminaire
0-10	135.6	4.0%
10-20	405	12.0%
20-30	610.5	18.2%
30-40	670.7	19.9%
40-50	596.4	17.7%
50-60	454.4	13.5%
60-70	297	8.8%
70-80	152.1	4.5%
80-90	40.6	1.2%



(Lumens Per Zone)

Wall Graze
Test Report: ISF 201613P73
IES LM79-08
S1LWD 4FT 90CRI 35K 1000LMF WG
Lumens: 3403.9
Wattage: 37.82
Efficacy: 90.0026441

Zonal Lumen Summary		
Zone	Lumens	% Luminaire
0-10	202	5.9%
10-20	498.3	14.6%
20-30	618.5	18.2%
30-40	627.7	18.4%
40-50	556.3	16.3%
50-60	429.9	12.6%
60-70	283.9	8.3%
70-80	147.1	4.3%
80-90	40.1	1.2%

EXPECTED LIFE: L80 @ 60,000 HOURS

CCT SCALING CHART

CCT	CRI	MULTIPLIER
27K	90CRI	.96
30K	90CRI	.98
35K	90CRI	1
40K	90CRI	1.01
50K	90CRI	.98

OPTICAL SCALING CHARTS

DISTRIBUTIONS	MULTIPLIER
LAMBERTIAN	1
DBW	0.8

SHEILDING	MULTIPLIER
QCGFW	0.81
QCGFB	0.52
DRP05	1.11
DRP1	1.13
DRP15	1.17
EGLD	1.08

**Base fixture with lambertian distribution and flush lens*

LINEAR PLAN

Mark Lighting offers the ability to provide a continuous run plan to suit your requirements by optionally offering three different methods of configuration.

LLP- Linear Longest Possible
In this configuration, the longest length available is optimized, resulting in the fewest segments and mounting locations. Caution should be used where balanced appearance is a concern. Example: 20 FT run would have 2, 8 FT segments and 1, 4 FT segment at the end of the run.

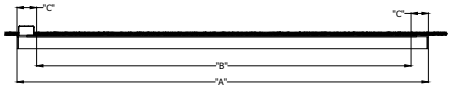
LLP	8 FT	8 FT	4FT

LCB- Linear Center Balanced:
This configuration incorporates the longest center segment(s) along with any additional lengths required to fill the run length, added to the run ends. Example: 16 FT run would have 2, 4 FT segments (one at each end) and 1, 8 FT segment in the center.

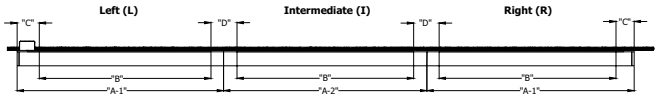
LCB	4 FT	8 FT	4FT

LSL- Linear Same Length:
In this configuration, each segment is the same length and is standardized based on the longest length available and is the only option provided. Because it is dependent on one segment length and there are mathematical limitations on what overall row lengths can be achieved. Example: 20 FT row would be achieved with 5, 4 FT long segments equaling 20 FT (nominal).

LSL	4FT	4FT	4FT	4FT	4FT

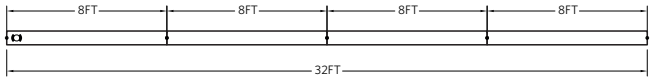


INDIVIDUAL FIXTURES				
ORDERED LENGTH	"A" O.A.L.	"B" O.C.	"C" FROM END	APPROX. WEIGHT
2FT	2'- 3/8"	1'- 4"	4 3/16"	3LB
3FT	3'- 3/8"	1'- 4"	10 3/16"	5LB
4FT	4'- 3/8"	2'- 8"	8 3/16"	7LB
5FT	5'- 3/8"	4'	6 3/16"	8LB
6FT	6'- 3/8"	5'- 4"	4 3/16"	10LB
7FT	7'- 3/8"	5'- 4"	10 3/16"	11LB
8FT	8'- 3/8"	6'- 8"	8 3/16"	13LB

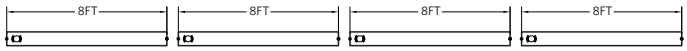


RUN LAYOUT						
ORDERED LENGTH	"A-1" O.A.L.	"A-2" O.A.L.	"B" MOUNT POINT	"C" FROM END	"D"	APPROX. WEIGHT
4FT	4'- 3/16"	4'-0"	2'- 8"	8 3/16"	1'-4"	7LB
5FT	5'- 3/16"	5'-0"	4'	6 3/16"	1'	8LB
6FT	6'- 3/16"	6'-0"	5'- 4"	4 3/16"	8"	10LB
7FT	7'- 3/16"	7'-0"	5'- 4"	10 3/16"	1'-8"	11LB
8FT	8'- 3/16"	8'-0"	6'- 8"	8 3/16"	1'-4"	13LB

Total Run Length
This system is not modular. Runs longer that 8FT will be automatically configured with left, intermediate and right sections, based on how you specify the TOTAL RUN LENGTH and MAXIMUM SECTION LENGTH parameters in the ordering information. Always order the total run length, not the individual sections.



Example: This run must be ordered as 1pc "S1LWD LLP 32FT MSL8..."



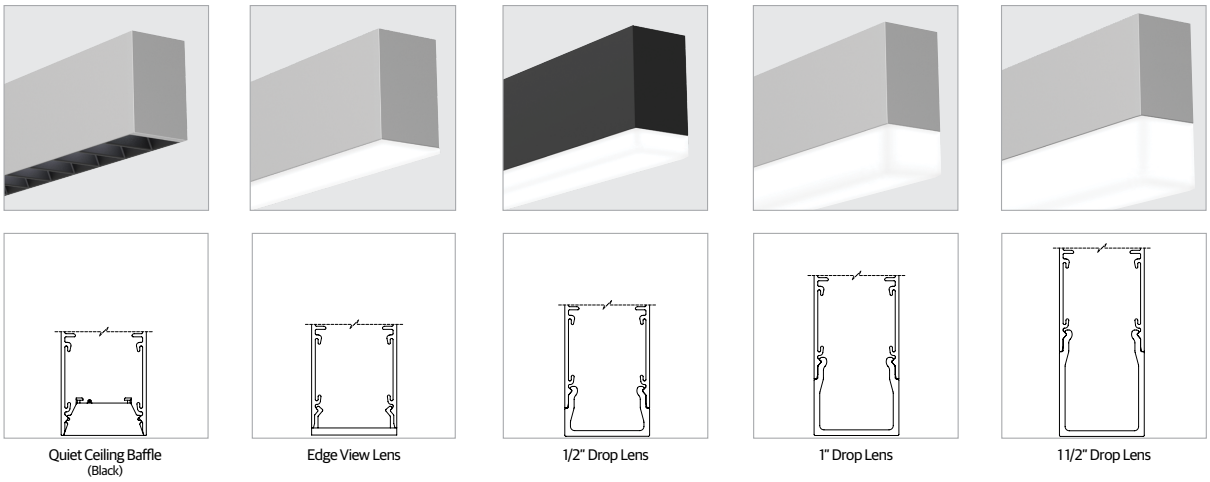
Example: If you order as 4pcs "S1LWD LLP 8FT MSL8... you will receive these INDIVIDUAL sections that cannot be joined together

Maximum Section Length
The run will be broken out using as many sections at the chosen MSL length as possible. Shorter sections will then complete the desired run length.

Examples:
S1LWD LLP 21FT MSL5... = 5FT / 4FT / 4FT / 4FT / 4FT
S1LWD LLP 21FT MSL6... = 6FT / 6FT / 5FT / 4FT
S1LWD LLP 21FT MSL7... = 7FT / 7FT / 7FT
S1LWD LLP 21FT MSL8... = 8FT / 8FT / 5FT

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

SHIELDING



Quiet Ceiling Baffle (Black)

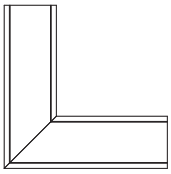
Edge View Lens

1/2" Drop Lens

1" Drop Lens

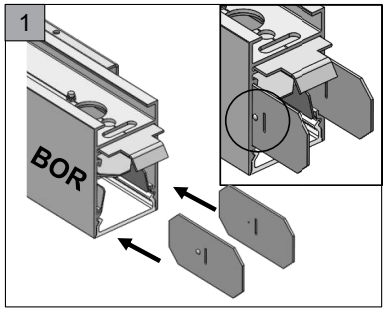
1 1/2" Drop Lens

Run Patterns, Corners and Junction
Slot 1 LED patterns can be configured in 1' increments with illuminated 90° standard 2' corner. For custom angles, corner or junction lengths, consult factory.
See separate patterns spec sheet for more details.

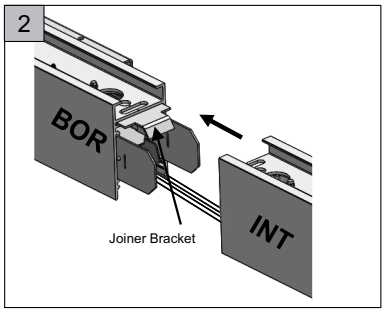


90º Corner

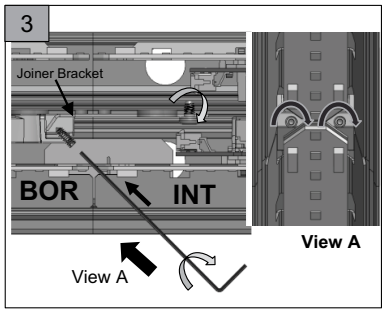
JOINERS



Step 1: Align

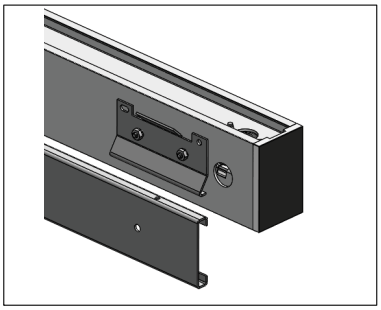


Step 2: Engage



Step 3: Lock

MOUNTING



INTELLIGENT LUMINAIRE CHARTS

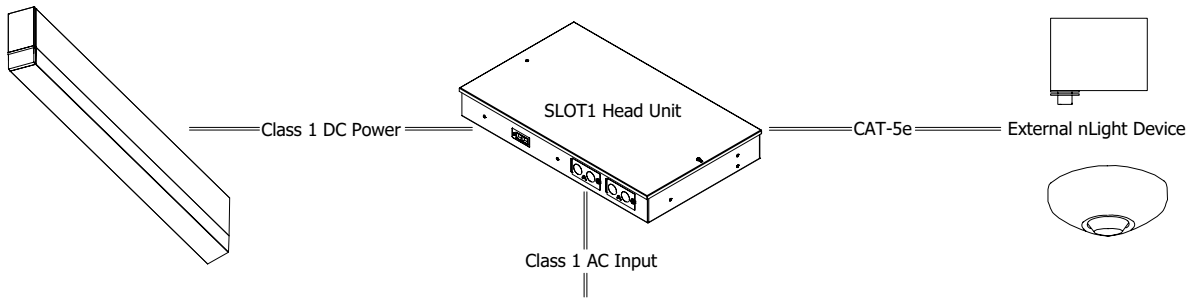
Choose nomenclature from these columns

Driver Configurations	Minimum Dimming Level	Control Input	Driver	Dimming Range	Notes
	MIN1	DALI	eldoLED DCDC DUALdrive	100 to 1%	Logarithmic Dimming, DALI controls and power supply supplied by others
	MIN1	ZT	eldoLED DCDC DUALdrive	100 to 1%	Linear Dimming, supplied with leads for two independent zones of 0-10V
	MIN1	NLIGHT	eldoLED DCDC DUALdrive	100 to 1%	Logarithmic Dimming, nIO EZDCA 16Z in head unit
	MIN1	NLTAIR2	eldoLED DCDC DUALdrive	100 to 1%	Logarithmic Dimming, rIO EZDL in head unit with external antenna
	MIN1	TUWH NLT	eldoLED DCDC DUALdrive	100 to 1%	Logarithmic Dimming, nIO EZDCA CCT in head unit
	DARK	DALI	eldoLED DCDC DUALdrive	100 to 0.1%	Logarithmic Dimming, DALI controls and power supply supplied by others
	DARK	ZT	eldoLED DCDC DUALdrive	100 to 0.1%	Linear Dimming, supplied with leads for two independent zones of 0-10V
	DARK	NLIGHT	eldoLED DCDC DUALdrive	100 to 0.1%	Logarithmic Dimming, nIO EZDCA 16Z in head unit
	DARK	NLTAIR2	eldoLED DCDC DUALdrive	100 to 0.1%	Logarithmic Dimming, rIO EZDL in head unit with external antenna
	DARK	TUWH NLT	eldoLED DCDC DUALdrive	100 to 0.1%	Logarithmic Dimming, nIO EZDCA CCT in head unit

CONTROLS

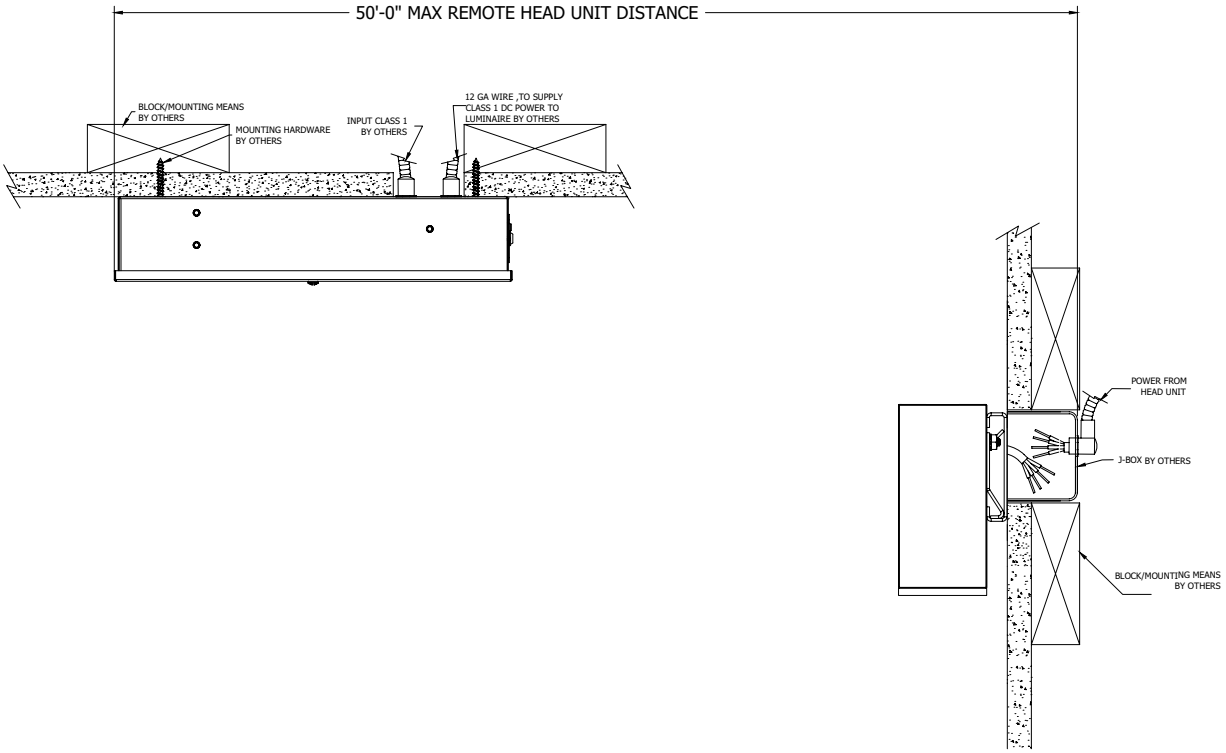
Remote sensors can be paired with NLIGHT options to control your runs.

SLOT1 Luminaire



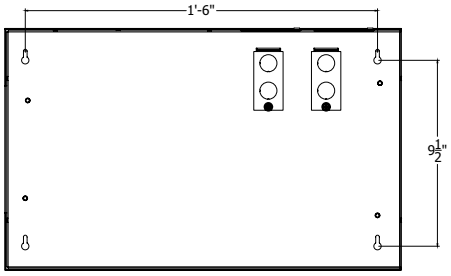
REMOTE HEAD UNITS

F2 CEILING DETAILS

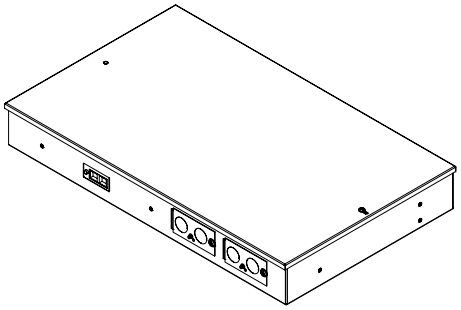


F2 HEAD UNIT DETAILS

MOUNTING LOCATIONS

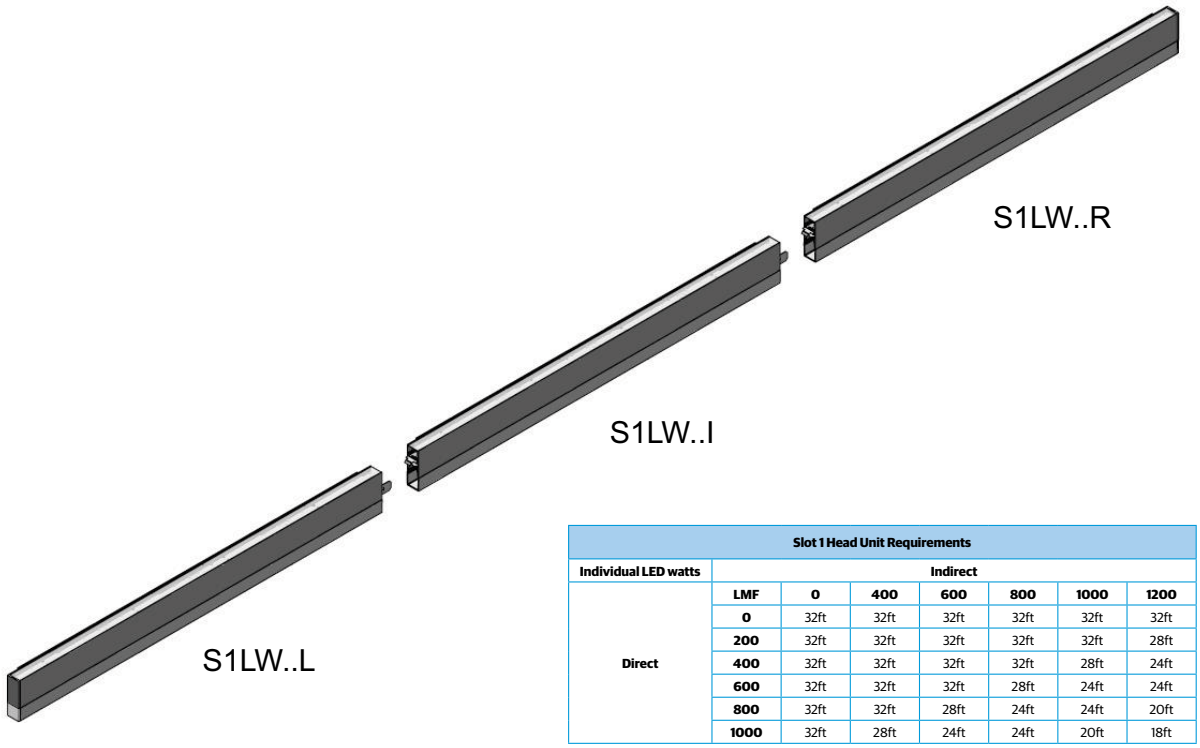


OVERALL DIMENSIONS
1'-8¼" x 1'-⅜" x 2⅝"



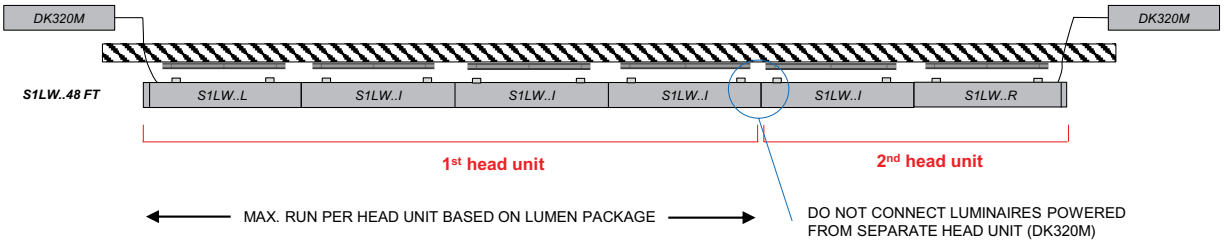
REMOTE HEAD UNITS

TYPES OF LAYOUT RUN



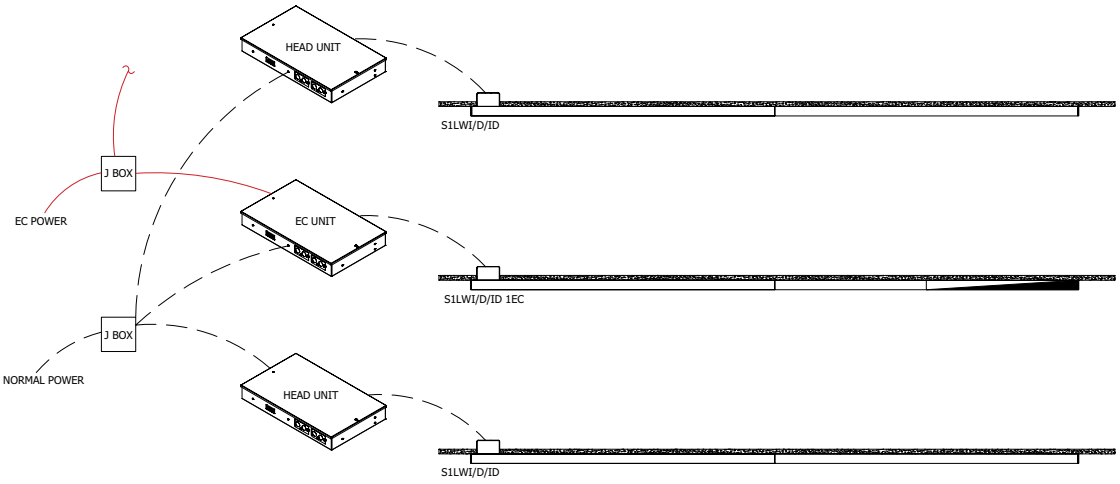
Slot 1 Head Unit Requirements							
Individual LED watts	**Indirect**						
	LMF	**0**	**400**	**600**	**800**	**1000**	**1200**
Direct	**0**	32ft	32ft	32ft	32ft	32ft	32ft
	200	32ft	32ft	32ft	32ft	32ft	28ft
	400	32ft	32ft	32ft	32ft	28ft	24ft
	600	32ft	32ft	32ft	28ft	24ft	24ft
	800	32ft	32ft	28ft	24ft	24ft	20ft
	1000	32ft	28ft	24ft	24ft	20ft	18ft

Footage indicates at what length, a new head unit will be required.



PLAN VIEW
TYPICAL LUMINAIRE LAYOUT
(*MOUNTING POINTS CAN VARY BASED ON CONFIGURATIONS)

TYPICAL BUILDING LAYOUT



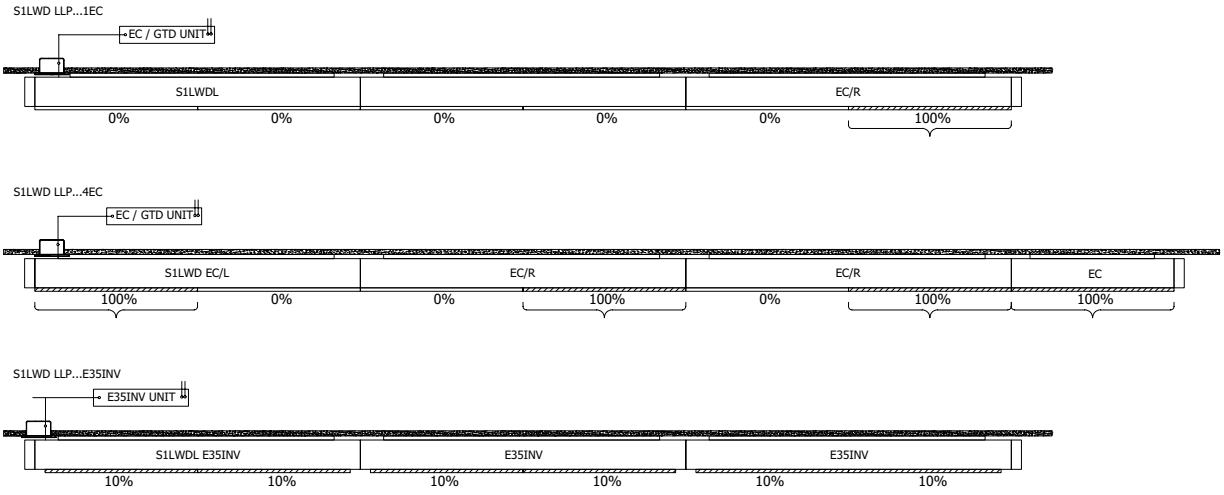
EMERGENCY OPTIONS

S1LWD

Emergency Options:

EC circuits default to the right side 4' section, of an 8' fixture (EC/R) and the complete section of a 4' fixture (EC/L).
Single EC circuit defaults to the last 4' of the run.
Dual EC circuits default to the last 4' of the run and the first 4' of the run.
Additional circuits will be added from the end of the run using the last 4' of an 8' fixture or complete 4' fixtures.
If the final fixture is a 2' fixture, the EC circuit will be placed at the next available 4' or 8' fixture section from the end of the run.

EXAMPLES OF TYPICAL EMERGENCY LAYOUTS.



SPECIFICATIONS

Housing
Nominal 2.3125" x 1.5" extruded aluminum housing

Finish
White, Black or Silver powdercoat

Reflector
Formed steel with high reflectance white

Distribution/Shielding
Wall Wash (WW), Wall Graze (WG) and Direct Batwing (DBW) are available to provide precides distribution for specific applications. Shielding is available by using a Quiet Ceiling Baffle (not available with specific optics) that aids in hiding the light source from normal view.

LED Components
Linear: Nichia®- 757 series LED chips (>80 CRI)

Electrical
Long-life LEDs, coupled with high-efficiency drivers, provide superior quantity and quality of illumination for extended service life. 80% LED lumen maintenance at 60,000 hours (L80/60,000).

Modulus Remote Power and Control System
Remote power source provides "natural dimming" with smooth, continuous and flicker-free dimming to dark (0.1%). Syncing for controls: 2mA max.

THD: <10%. Insignificant inrush current at 120 and 277VAC. FCC Class A and B tested for EMI and RFI. When NLIGHT or DALI is specified driver will be set for logarithmic dimming curve. If control Input of 0-10V is specified driver will be set for linear dimming curve.

Integrated digital nLight® module enables 4 channel wired networking via Cat-5e, when nLight® is selected. For daylight dimming and / or dual technology detection, see controls page for external sensor options.

Color Consistency
The Acuity Brands circuit boards for the linear LED components use a precise binning algorithm which creates a consistent color temperature from board to board. The color a variation of no greater than a 2.5 Step MacAdam (2.5SDCM) along the black body locus from board to board.

Driver
eldoLED® driver provides natural dimming with smooth, continuous and flicker-free deep dimming. Supports operation between 120 VAC and 277 VAC, with low inrush current (NEMA 410) and THD < 20%. Meets FCC Title 47 C.F.R. 15 Class A or Class B requirements. Lutron high performance driver options also available.

Certification
Tested to UL 2108 standards.

Warranty
5-year limited warranty. Complete warranty terms located at:
www.acuitybrands.com/CustomerResources/Terms_and_conditions.aspx

Note: *Actual performance may differ as a result of end-user environment and application. All values are design or typical values, measured under laboratory conditions at 25 °C. Specifications subject to change without notice.*

BeveLED Block® Surface - BLRD5 Round Downlight

USAI Lighting

SURFACE MOUNT

CONDUIT CUT OUT

usailighting.com/block

Keep ceiling height right where it is! Specifically designed to work with surface-mounted conduit and junction boxes, BeveLED BLOCK has a modern look that's perfect for lofts, offices, and open architectural spaces. Also available with solid-sides styling shown above, Block also creates a finished look when recessed conduit is possible.

FEATURES

- High performance architectural lighting solution for industrial or exposed concrete ceiling types where recessed lighting is not an option
- Convenient conduit cutouts provide access for surface-mounted conduit to pass through the luminaire
- Smooth, modular solid and keyhole slots are interchangeable and user configurable to allow for simple on site customization in the field.
- BeveLED BLOCK is available in a range of standard and custom colors to complement your project, whether an industrial or refined look is desired.
- Industry leading illumination and craftsmanship

BEVELED BLOCK DOWNLIGHT PERFORMANCE DATA

LED COLOR CHOICES

DELIVERED* PERFORMANCE:	Classic White								Warm Glow Dimming	
	9W		12W		16W		24W		16W	
Coloring Rendering Index:	80+	90+	80+	90+	80+	90+	80+	90+	80+	90+
Source Lumens:	1150	900	1300	1025	1725	1350	2400	1875	1275	1025
Lumens Per Watt:	93	68	86	67	86	67	80	63	69	55
Delivered Lumens:	775	600	1025	800	1375	1075	1925	1500	1100	875

*Performance based on 3000K. See IES files for exact values at usailighting.com.

CORRELATED COLOR TEMPERTURE	Classic White									Warm Glow Dimming				
	2200K	2700K		3000K		3500K		4000K		2700K		3000K		3500K
Coloring Rendering Index:	80+	80+	90+	80+	90+	80+	90+	80+	90+	80+	90+	80+	90+	80+
Multiplier for Lumen Output:	0.72	0.94	0.78	1.00	0.78	1.00	1.00	1.06	1.06	0.94	0.79	1.00	0.81	1.00

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New Windsor, NY 12553

BeveLED Block® Surface - BLRD5
Round Downlight with Integral Driver

USAI Lighting

FAMILY | LED COLOR CHOICES | FIXTURE

BLRD5								
BeveLED Block Downlight	**Wattage Options**	**LED Color Temperature Options**	**Beam Options**	**Lens Options**	**Body Finish Options**	**Mounting Options**	**Voltage Options**	**Dimming Driver Options**
BLRD5 BeveLED BLOCK 5" Round Downlight	**Classic White**						**For use with CC and SJ Mounting**	
	09C3 9W LED **12C3** 12W LED **16C3** 16W LED **24C3** 24W LED	**22KS** 2200K, 80+ CRI **27KS** 2700K, 80+ CRI **27KH** 2700K, 90+ CRI **30KS** 3000K, 80+ CRI **30KH** 3000K, 90+ CRI **35KS** 3500K, 80+ CR **35KH** 3500K, 90+ CRI **40KS** 4000K, 80+ CR **40KH** 4000K, 90+ CRI	**25** 25° beam **50** 50° beam **90** 90° beam	**S** Solite (provided standard) **BF** Borosilicate Frosted **SF** Solite Frosted	**WH** White **BZ** Bronze **BL** Black **GR** Grey **SC** Conduit Silver **RAL** Custom Color (specify RAL #)	**CC** Conduit cutout for surface mounted 4" octagonal junction box **SJ** Surface mounted to surface mounted 4" octagonal junction box	**UNV** 120V-277V	***For use with Universal Voltage 120V - 277V*** **D2** 0-10V dim, 10% (provided standard)
							120V	***For use with 120V only*** **D19** Phase dimming 1%, 120V only (1, 3)
	Warm Glow Dimming						**For use with RB Mounting Only**	
	16WG2 16W LED	**2722KS** 2700K-2200K, 80+ CRI **2722KH** 2700K-2200K, 90+ CRI **3022KS** 3000K-2200K, 80+ CRI **3022KH** 3000K-2200K, 90+ CRI **3522KS** 3500K-2200K, 80+ CRI	**30** 30° beam **50** 50° beam **90** 90° beam			**RB** Surface mounted to recessed mounted 4" octagonal junction box	**UNV** 120V-277V	***For use with Universal Voltage 120V - 277V*** **D2** 0-10V dim, 10% (provided standard) **D4A** Lutron ECO, 0.1% (2, 3, 4) **D4E** Lutron 5 ECO, 5% (1, 2, 3) **D4H** Lutron H ECO, 1% Fade (1, 2, 3) **D4P** Lutron ECO, 1% (2, 4) **D6A** EldoLED 0-10V, 0.1% (2) **D6B** EldoLED 0-10V, 0.1% (2) **D6E** EldoLED 0-10V, 1% (2) **D6F** EldoLED 0-10V, 1% (2) **D7** EldoLED DALI, 0.1% (2)
							120V	***For use with 120V only*** **D3** Lutron Hi-Lume 1% 2-wire, 120V only (2) **D19** Phase dimming 1%, 120V only (1, 3)

1 Not available with 9W
2 For use with RB mounting only
3 Not available for Warm Glow
4 Not available with 24W

FINISH OPTIONS

White (WH) | Bronze (BZ) | Black (BL) | Grey (GR) | Conduit Silver (SC)

Custom colors also available

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1126 River Road
New Windsor, NY 12553

BeveLED Block® Surface - BLRD5
Round Downlight with Remote Driver

USAI Lighting

FAMILY | LED COLOR CHOICES | FIXTURE

BLRD5							RM
BeveLED Block Downlight	**Wattage Options**	**LED Color Temperature Options**	**Beam Options**	**Lens Options**	**Body Finish Options**	**Mounting Options**	**Remote Power Supply**
	Classic White						
BLRD5 BeveLED BLOCK 5" Round Downlight	**09C3** 9W LED **12C3** 12W LED **16C3** 16W LED **24C3** 24W LED	**22KS** 2200K, 80+ CRI **27KS** 2700K, 80+ CRI **27KH** 2700K, 90+ CRI **30KS** 3000K, 80+ CRI **30KH** 3000K, 90+ CRI **35KS** 3500K, 80+ CR **35KH** 3500K, 90+ CRI **40KS** 4000K, 80+ CR **40KH** 4000K, 90+ CRI	**25** 25° beam **50** 50° beam **90** 90° beam	**S** Solite (provided standard) **BF** Borosilicate Frosted **SF** Solite Frosted	**WH** White **BZ** Bronze **BL** Black **GR** Grey **SC** Conduit Silver **RAL** Custom Color (specify RAL #)	**CC** Conduit cutout for surface mounted 4" octagonal junction box **SJ** Surface mounted to surface mounted 4" octagonal junction box **RB** Surface mounted to recessed mounted 4" octagonal junction box	**RM** Remote Power Supply (Specify in table below) USAI Power Supply Must Be Specified
	Warm Glow Dimming						
	16WG2 16W LED	**2722KS** 2700K-2200K, 80+ CRI **2722KH** 2700K-2200K, 90+ CRI **3022KS** 3000K-2200K, 80+ CRI **3022KH** 3000K-2200K, 90+ CRI **3522KS** 3500K-2200K, 80+ CRI	**30** 30° beam **50** 50° beam **90** 90° beam				

2. Specify Remote Power Supply

RPC-01				
Remote Power Supply	**Wattage Options**	**Voltage**	**Remote Dimming Type and Level**	**Remote Emergency Option**
RPC-01 BeveLED Block Remote Power Supply	**Classic White** **09C3** 9W LED **12C3** 12W LED **16C3** 16W LED **24C3** 24W LED	**UNV** 120V - 277V	**D4A** Lutron ECO, 0.1% (2, 3) **D4E** Lutron 5 ECO, 5% (1, 2) **D4H** Lutron H ECO, 1% Fade (1, 2) **D4P** Lutron ECO, 1% (3) **D6A** EldoLED 0-10V, 0.1% **D6B** EldoLED 0-10V, 0.1% **D6E** EldoLED 0-10V, 1% **D6F** EldoLED 0-10V, 1% **D7** EldoLED DALI, 0.1% **D18** Moon's DMX, 0.1% (2)	**EM5** EM battery requires remote enclosure by others, minimum size 11" L x 6.75" W x 3.25" H
	Warm Glow **16WG2** 16W LED	**120V** 120V Only	**D3** Lutron 2-wire, 1% **D19** Hatch Phase 2-wire, 1% (1, 2)	

1 Not available for 9W
2 Not available for Warm Glow
3 Not available for 24W

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BeveLED Block® Surface - BLRD5 Round Downlight

USAI Lighting

KEY ACCESSORIES

CONDUIT CUTOUT KEYS

Each conduit cutout mounting option (CC style) is provided with three conduit cutout keys (KAR-CC-xx) and three solid cover keys (KAR-VK-xx) in the fixture finish specified. For more keys, or for extended length keys, please use the ordering table below.

KEY ACCESSORY ORDERING INFORMATION

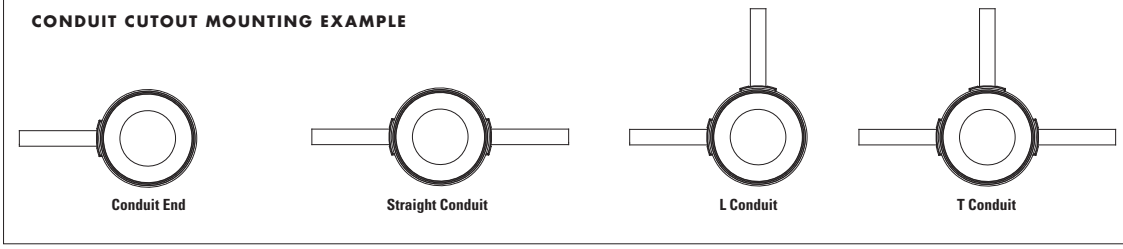
Fixture Family	Key Accessory	Finish
KAR Key Accessory Round	**CC*** Conduit Cutout Key **XC** Conduit Cutout Key, Extended Length **VK*** Solid Cover Key *3 provided with each conduit cutout canopy	**WH** White **SC** Conduit Silver **GR** Grey **BL** Black **BZ** Bronze **RAL** Custom Color

ROUND CONDUIT CUTOUT KEY (STANDARD) KAR-CC

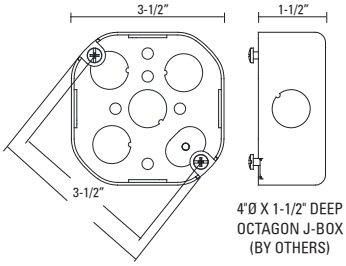
ROUND CONDUIT CUTOUT KEY EXTENDED DEPTH KAR-XC

ROUND SOLID COVER KEY (STANDARD) KAR-VK

CONDUIT CUTOUT MOUNTING EXAMPLE



4"OCTAGONAL JUNCTION BOX DETAIL



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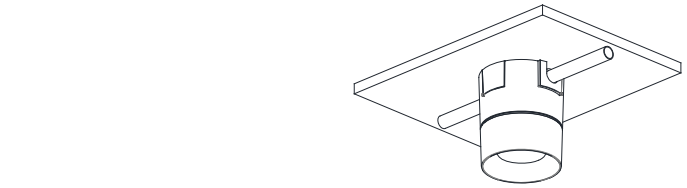
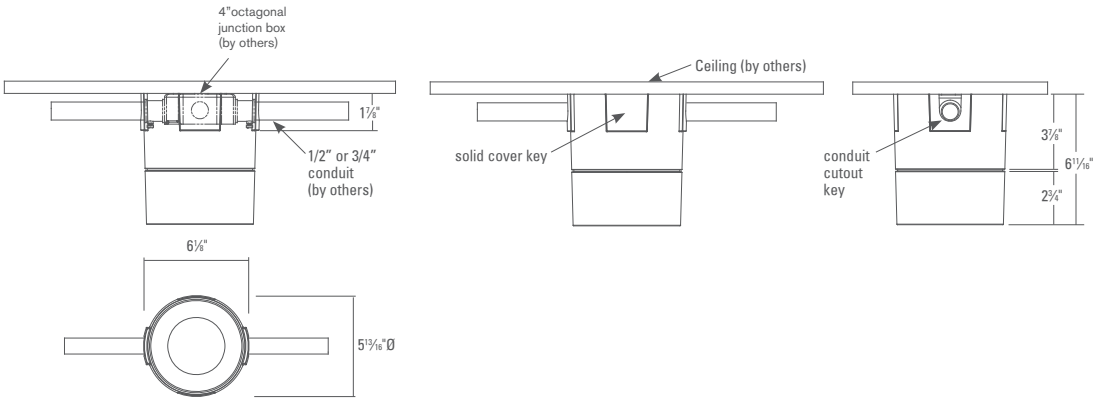
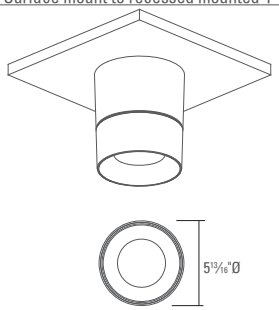
CC - CONDUIT CUTOUT MOUNTED

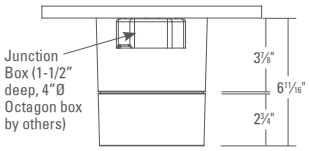




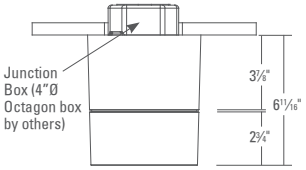
SJ - Surface mount to surface mounted 4"octagonal j-box
RB - Surface mount to recessed mounted 4"octagonal j-box



SJ - Surface mount to surface mounted 4"octagonal j-box



RB - Surface mount to recessed mounted 4"octagonal j-box



See drawing above for junction-box (by others) details.

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BEVELED BLOCK SPECIFICATIONS

FIELD REPLACEABLE LED LIGHT ENGINE
is serviceable without tools. All USAI Lighting Classic White and Warm Glow Dimming light engines feature industry-leading color consistency

FIELD REPLACEABLE DRIVER
0-10V, 100%-10% solid state electronic constant current D2 dimming driver with a high power factor provided standard and sources 2mA. Other dimming drivers optionally available. D6 dimming drivers source 2mA. Driver complies with IEEE C62.41 surge protection. Some on-time delay may be experienced depending on control system used.

REMOTE LOCATION DRIVER
If a remote dimming driver is required, specify "RM" in the fixture part number and proceed to the RP table to complete the dimming driver specification. All remote power supplies must be clearly specified in the "RP" table, with one remote power supply required per fixture. Remote power supplies require enclosures by others that meet local codes and must be located in an accessible service panel within 100ft of the light fixture; see table below for coordination of enclosure sizes. All dimming drivers comply with IEEE C62.41 surge protection.

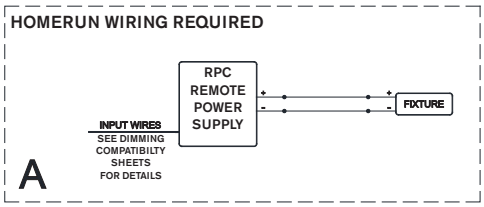
REMOTE LOCATION EMERGENCY
Remote emergency battery IOTA ILB-CP05 provides 5W to one fixture for 90 minutes. Remote power supplies with EM option require an enclosure by others with minimum size of 11"L x 6.75"W x 3.25"H that meets local codes. Emergency battery remote power supplies cannot be located any more than 50 feet from light fixture.

BEVELED BLOCK REMOTE POWER SUPPLY REQUIREMENTS AND WIRING DIAGRAM

Remote Power Supply	Dimming Option		Wire Gauge Required*	Minimum Enclosure Size Required (by others) RP Only	RP with EM Option**
RPC-01-09C3 RPC-01-12C3 RPC-01-16C3 RPC-01-24C3 RPC-01-16WG2	**UNV-D4A**	Lutron ECO, 0.1% (2, 3)	14/12	6.25" L x 4" W x 2" H	11" L x 6.75" W x 3.25" H
	UNV-D4E	Lutron 5 ECO, 5% (1, 2)			
	UNV-D4H	Lutron H ECO, 1% fade (1, 2)			
	UNV-D4P	Lutron ECO, 1% (3)			
	UNV-D6A	EldoLED 0-10V, 0.1%	18/16		
	UNV-D6B	EldoLED 0-10V, 0.1%			
	UNV-D6E	EldoLED 0-10V, 1%			
	UNV-D6F	EldoLED 0-10V, 1%			
	UNV-D7	EldoLED DALI, 0%			
	UNV-D18	Moon's DMX 0.1% (2)	18/16	9" L x 4" W x 2" H	
	120V-D3	Lutron 2-wire phase, 1%	14/12	6.25" L x 4" W x 2" H	
	120V-D19	Hatch 2-wire phase, 1% (1,2)	14/12	5.75" L X 2.625" W X 2" H	

1 Not available for 9W
2 Not available for Warm Glow
3 Not available with 24W

* Wire gauge 14/12 = Maximum distance from light fixture to remote power supply is 100' using 12 gauge wire, 50' using 14 gauge wire.
* Wire gauge 18/16 = Maximum distance from light fixture to remote power supply is 100' using 16 gauge wire, 50' using 18 gauge wire.
** Emergency battery remote power supplies cannot be located any more than 50 feet from light fixture.



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BeveLED Block® Surface - BLRD5
Round Downlight

USAI® Lighting

BEVELED BLOCK SPECIFICATIONS

FIXTURE WEIGHT
BeveLED Block weighs 5 lbs

BODY
5-13/16" round die cast aluminum body available in a variety of powder coated paint finishes. Custom colors also available (provide RAL #).

MOUNTING
CC: Conduit cutout mounting fixtures are designed to mount to surface-mounted 4"octagonal junction boxes with surface-mounted conduit connections. CC housings have 4 keyslots, one in each side, and ship with one conduit cutout key and three solid cover keys installed in the housing. 2 additional conduit cutout keys are shipped with the fixture, and the different key types are interchangeable in the field. Please see installation instructions for drawings and more details.
RB: Recessed ceiling 4" octagonal junction box mounting fixtures are designed to mount to a ceiling retaining a recessed 4"octagonal junction box. The sides are solid and have no cutouts, please see drawings and installation instructions for more details.
SJ: Surface mounted 4" octagonal junction box mounting fixtures are designed to mount to a surface-mounted junction box that has electrical supply coming from the plenum (no surface-mounted conduit). The sides are solid and have no cutouts, please see drawings and installation instructions for more details

WARRANTY
Based on IESNA LM80-2008, BeveLED Block has a 50,000 hour rated life at 70% lumen maintenance (L70). USAI Lighting Warranty covers replacement parts for 5 years from date of shipment.

LISTINGS
Dry/Damp/Wet for RB and SJ mounting. CC mounting style is dry/damp only. NRTL/CSA-US tested to UL standards. IBEW union made.

NOTES
• Ambient temperatures at fixture location should not exceed 40°C during normal operation.
• Consult factory for video capture applications.

PHOTOMETRICS
Consult factory or website for IES files. Tested in accordance with IESNA LM79. www.usailighting.com/block

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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D3 / DIML3

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

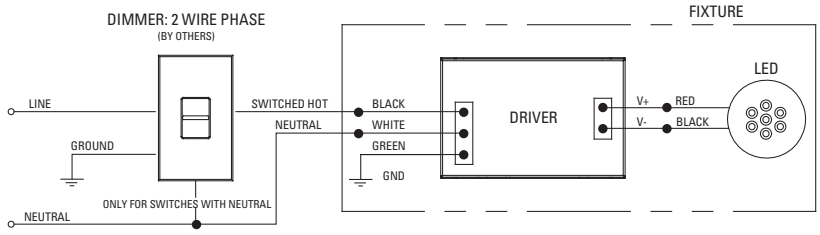
D3 / DIML3 LED: Lutron Hi-Lume A-Series 2 Wire Fwd Phase (with neutral) / LED Dimming Driver Wiring (Dims down to 1%) 120V

D3 / DIML3 Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Dimmer* Fixture Wattage	
120V Only				39W and Less	40W - 80W
ETC	Sensor+ Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
ETC	Unison DRd Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
Lutron	Maestro Wireless® 600W dimmer	MRF2-6ND-120-	100% - 1%	1 – 8	1 – 4
Lutron	Maestro Wireless® 1000W dimmer	MRF2-10ND-120-	100% - 1%	1 – 13	1 – 6
Lutron	HomeWorks® QS adaptive dimmer	HQRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 600W dimmer	HQRD-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 1000 W dimmer	HQRD-10ND-	100% - 1%	1 – 13	1 – 6
Lutron	Caseta Wireless® Pro 1000W dimmer	PD-10NXD-	100% - 1%	1 – 13	1 – 6
Lutron	Stanza® dimmer	SZ-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 adaptive dimmer	RRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 1000 W dimmer	RRD-10ND-	100% - 1%	1 – 6	1 – 3
Lutron	myRoom DIN power module	MQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® QS wallbox power module	HQRJ-WPM-6D-120-	100% - 1%	1 – 26	1 – 13
Lutron	Homeworks® DIN power module	LQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® wallbox power module	HWI-WPM-6D-120	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® QS control unit	QSGR-, QSGRJ-	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® 3000 control unit	GRX-3100-, GRX-3500-	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4U module	HW-RPM-4U-120, LP-RPM-4U-120	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4A module	HW-RPM-4A-120, LP-RPM-4A-120	100% - 1%	1 – 26	1 – 13
Lutron	GP dimming panels	Various	100% - 1%	1 – 26	1 – 13
Lutron	Ariadni CL 250W dimmer	AYCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Diva CL 250W dimmer	DVCL-253P-, DVSCCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Grafik T CL or RF CL dimmer	GT-250M-, GTJ-250M-	100%-1%	1 – 8	1 – 4
Lutron	Nova T CL 250W dimmer	NTCL-250-	100%-1%	1 – 10	1 – 5

* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D3 / DIML3
2 WIRE PHASE DIMMING



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I2-264-3 Revised 03/22/2017

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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D4A / DIML4A and D4P / DIML4P

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

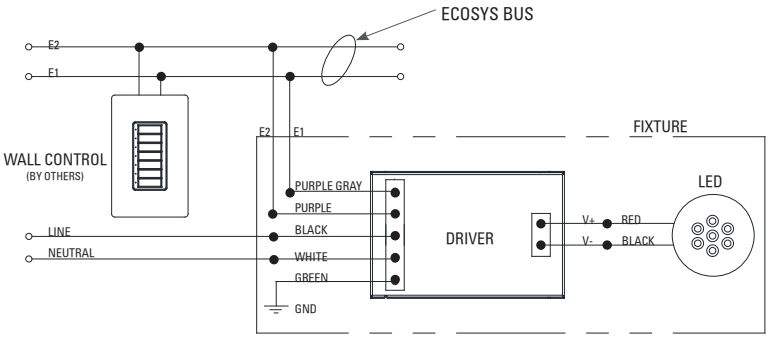
D4A / DIML4A LED: Lutron Hi-Lume Premier EcoSystem LED Driver (Dims down to 0.1%)
D4P / DIML4P LED: Lutron Hi-Lume Premier EcoSystem LED Driver (Dims down to 1%)

D4A / D4P EcoSystem Controls Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Maximum Quantity Light Fixtures Per Control
120V / 277V			
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	32
		FCJ/FCJS-ECO	3
120V ONLY			
Lutron	Energi Savr Node	QSN-1ECO-S	64
		QSN-2ECO-S	128
	GRAFIK Eye QS/ Homeworks QS control unit	QSGRJ-_ E, QSGR-_ E	64
	Quantum Hub	QP2-__2C	128
		QP2-__4C	256
		QP2-__6C	384
		QP2-__8C	512
	HomeWorks QS / myRoom Plus power module	LQSE-2ECO-D	128

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D4A / DIML4A and D4P / DIML4P
EcoSystem CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D4E / DIML4E and D4H /DIML4H

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

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4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D4E / DIML4E LED: Lutron 5 Series EcoSystem LED Driver / LED Dimming Driver Wiring (Dims down to 5%)

D4E / DIML4E EcoSystem Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V / 277V				39W and Less	40W - 80W
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	100%–5%	1–32	1–16
Lutron	Energi Savr Node	QSN-1ECO-S, QSN-2ECO-S	100%–5%	1–64	1–32
Lutron	GRAFIK Eye QS (120V ONLY)	QSGRJ- E, QSGR- E	100%–5%	1–64	1–32
Lutron	Quantum	Various	100%–5%	1–64	1–32

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

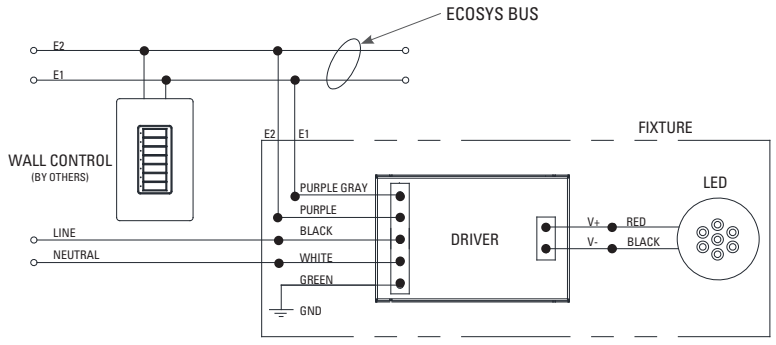
D4H / DIML4H LED: Lutron H Series EcoSystem LED Driver with Fade to Black (dims down to 1%)

D4H / DIML4H EcoSystem Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V / 277V				39W and Less	40W - 80W
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	100%–1%	1–32	1–16
Lutron	Energi Savr Node	QSN-1ECO-S, QSN-2ECO-S	100%–1%	1–64	1–32
Lutron	GRAFIK Eye QS (120V ONLY)	QSGRJ- E, QSGR- E	100%–1%	1–64	1–32
Lutron	Quantum	Various	100%–1%	1–64	1–32

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D4E / DIML4E and D4H / DIML 4H EcoSystem CONTROLS



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I2-264-4EH Revised 03/22/2017

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

USAI Lighting

DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D6A / DIML6A and D6E / DIML6E
D6B / DIML6B and D6F / DIML6F

IMPORTANT SAFETY INSTRUCTIONS
- SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
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4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D6A / DIML6A and D6E / DIML6E LED Dimming Compatibility Table

D6A / DIML6A and D6E / DIML6E are linearly programmed dimming drivers for use with the dimming controls listed in the table below.
D6A / DIML6A = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1%
D6E / DIML6E = EldoLED ECOdrive 0-10V control dims from 100% to 1%

D6A / DIML6A and D6E / DIML6E Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range			Qty Fixtures Per Dimmer*
120V & 277V			DIML6A		6E	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Lutron	Diva	DVTV/NFTV with PP-20	99% -	0.1%	1%	
Lutron	Nova T	NTFTV with PP-20	99% -	0.1%	1%	
Lutron	Energi Savr Node	QSN-4T16-S	100% -	0.1%	1%	
Lutron	GP Dimming Panels	TVM2 Module	99% -	0.1%	1%	
Lutron	Interfaces	GRX-TVI w/ GRX3503	100% -	0.1%	1%	
Sensor Switch	nIO	nIO EZ	100% -	0.1%	1%	
enlighted	Control Unit	CU-3E-1R	100% -	0.1%	1%	

D6B / DIML6B and D6F / DIML6F LED Dimming Compatibility Table

D6B / DIML6B and D6F / DIML6F are logarithmic-programmed dimming drivers for use with the dimming controls listed in the table below.
D6B / DIML6B = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1% D6F / DIML6F = EldoLED ECOdrive 0-10V control dims from 100% to 1%

D6B / DIML6B and D6F / DIML6F Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range			Qty Fixtures Per Dimmer*
120V & 277V			DIML6B		6F	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Bush-Jaeger	Electronic potentiometer	2112U-101	100% -	0.1%	1%	
Jung	Electronic potentiometer	240-10	100% -	0.1%	1%	
Leviton	Iluma Tech dimmer	IP710-DLX	100% -	0.1%	1%	
Lightolier (Philips)	Momentum (120V ONLY)	ZP600FAM120	100% -	0.1%	1%	
Merten	Electronic potentiometer	5729	100% -	0.1%	1%	
Pass & Seymour	Titan	CD4FB-W	100% -	0.1%	1%	
Watt Stopper	Miro	DCLV1	100% -	0.1%	1%	
Synergy	Wallbox Dimmers	ISD BC	100% -	0.1%	1%	
ABB	i-bus	SD/S 2.16.1	100% -	0.1%	1%	
Crestron	Modules	GLX-DIMFLV8, GLXP-DIMFLV8	100% -	0.1%	1%	
Crestron	Green Light	GLPAC-DIMFLV4-, GLPAC-DIMFLV8-	100% -	0.1%	1%	
Crestron	Green Light Power Pack	GLPP-DIMFLVEX-PM, GLPP-1DIMFLV2EX-PM, GLPP-1DIMFLV3EX-PM	100% -	0.1%	1%	
Crestron	DIN Rail Analog Output Module	DIN-A08	100% -	0.1%	1%	
Crestron	DIN Rail 0-10V Fluorescent Dimmer	DIN-4DIMFLV4	100% -	0.1%	1%	
Crestron	iLux 0-10V Dimmer Expansion Module	CLS-EXP-DIMFLV	100% -	0.1%	1%	
enlighted	Control Unit	CU-3E-1R	100% -	0.1%	1%	

DIMMING DRIVER WIRING SCHEMES:

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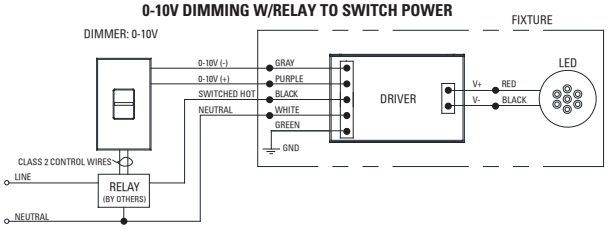
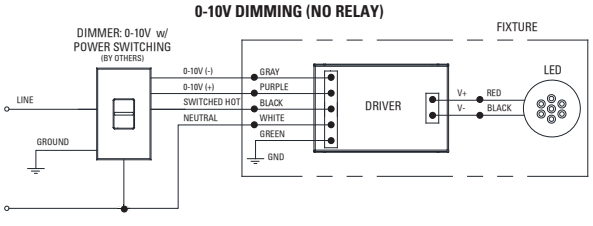
D6 / DIML6
0-10V DIMMING W/RELAY TO SWITCH POWER



D6 / DIML6
0-10V DIMMING (NO RELAY)



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1126 River Road
New Windsor, NY 12553
T 845–565–8500
F 845–561–1130

I2-264-6 Revised 08/16/2019

DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D7 / DIML7 and D7E

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

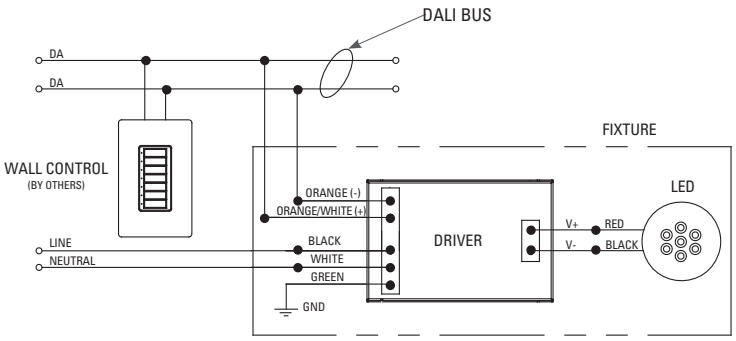
IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D7 / DIML7 and D7E Dimming Driver Wiring

D7 / DIML7 and D7E are linearly programmed dimming drivers.
D7 / DIML7 = EldoLED SOLOdrive DALI control dims from 100% to 0.1%
D7E = EldoLED ECOdrive DALI control dims from 100% to 1%

D7 / DIML7 / D7E
DALI CONTROLS



USAI Lighting
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I2-264-7 Revised 08/14/2017

USAI Lighting

DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D19 / DIML19

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

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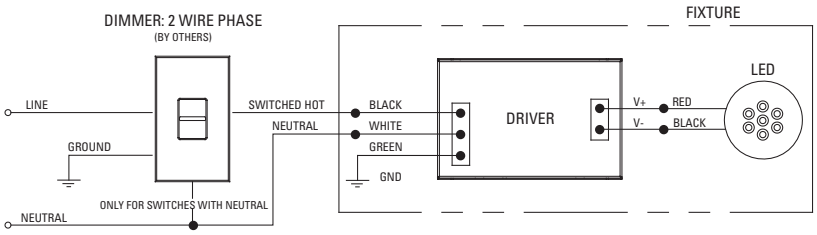
5. Cap any wires not used separately (not together).

D19 / DIML19 LED: Hatch XTC series or equivalent - Forward and Reverse Phase Dimming Driver. Dims down to 1% contingent upon dimmer specification and load. 120V only.

D19 / DIML19
2 WIRE PHASE DIMMING



D19 / DIML19 Dimmer Compatibility Chart

120V ONLY		
Forward Phase / TRIAC Dimming		
Manufacturer	Product	Qty Fixtures Per Dimmer
Leviton	IPL06-10Z	Use fixture wattage per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
	6613-xxx	
Lutron	S-600P	
	S-603P	
	DV-600P	
	DV-603P	
	DVSC-603P	
	CT-600P	
	CT-603P	

120V ONLY		
Reverse Phase / ELV Dimming		
Manufacturer	Product	Qty Fixtures Per Dimmer
Leviton	6615	Use fixture wattage per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
	IPE04-xxx	
Lutron	NTELV-300	
	NTELV-600	
	SELV-300P	
	SELV-303P	
	DVELV-300P	
	DVELV-303P	

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I2-264-19 Revised 03/22/2017

EXISTING LUMINAIRE TO BE REFURBISHED

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

ARCHIPELAGO LIGHTING
Lighting | Reinvented

NOSTALGIC
B10
COMMERCIAL GRADE

FILAMENT LED
60 Watt
REPLACEMENT

USES ONLY 4.5W

- NATURAL DIMMING – DIM TO OFF[2]
- SUITABLE FOR WET LOCATIONS
- ENCLOSED RATED
- 25,000 HOURS RATED LIFE
- 3-YEAR LIMITED WARRANTY
- 360° LIGHT DISTRIBUTION
- ENERGY STAR LISTED[3]
- UL LISTED

ALSO AVAILABLE IN:


FROSTED


MEDIUM BASE

Ordering Information (B10, 60W)

Model Number	Type	Base	Lumens	Wattage	MOL I MOD	CCT	CRI
LTB10C50024CB	Glass I Clear	E12 I Candelabra	450LM	4.0W	4.0” I 1.3”	2400K	83
LTB10C50027CB	Glass I Clear	E12 I Candelabra	450LM	4.0W	4.0” I 1.3”	2700K	83
LTB10C50024MB	Glass I Clear	E26 I Medium	450LM	4.5W	3.5” I 1.3”	2400K	83
LTB10C50027MB	Glass I Clear	E26 I Medium	450LM	4.5W	3.5” I 1.3”	2700K	83
LTB10F50024CB	Glass I Frosted	E12 I Candelabra	450LM	4.0W	4.0” I 1.3”	2400K	83
LTB10F50027CB	Glass I Frosted	E12 I Candelabra	450LM	4.0W	4.0” I 1.3”	2700K	83
LTB10F50024MB	Glass I Frosted	E26 I Medium	450LM	4.5W	3.5” I 1.3”	2400K	83
LTB10F50027MB	Glass I Frosted	E26 I Medium	450LM	4.5W	3.5” I 1.3”	2700K	83

NOTE 1: Alternative CCTs are available as special order. Please contact *sales@archipelagolighting.com* for more information.
NOTE 2: Please reference dimmer compatibility list at *www.archipelagolighting.com*
NOTE 3: Please look for the Energy Star logo for listed products.

RoHS 2002/95/EC Pb lead-free ENERGY STAR PARTNER

ARCHIPELAGO LIGHTING, INC. I 4615 State Street, Montclair CA, 91763 I t: (866) 912-3220 I f: (909 627-2887

EXISTING LUMINAIRE TO BE REFURBISHED

ARCHIPELAGO LIGHTING
Lighting | Reinvented

NOSTALGIC
A19
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FILAMENT LED
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- ENERGY STAR LISTED[3]
- UL LISTED

ALSO AVAILABLE IN:


SILVER-TIP


FROSTED

Ordering Information (A19, 60W)

Model Number	Type	Base	Lumens	Wattage	MOL I MOD	CCT	CRI
LTA19C80024MB	Glass I Clear	E26 I Medium	800LM	7.5W	4.1" I 2.4"	2400K	83
LTA19C80027MB	Glass I Clear	E26 I Medium	800LM	7.5W	4.1" I 2.4"	2700K	83
LTA19C80030MB	Glass I Clear	E26 I Medium	800LM	7.5W	4.1" I 2.4"	3000K	83
LTA19C80041MB	Glass I Clear	E26 I Medium	800LM	7.5W	4.1" I 2.4"	4100K	83
LTA19F80024MB	Glass I Frosted	E26 I Medium	800LM	7.5W	4.1" I 2.4"	2400K	83
LTA19F80027MB	Glass I Frosted	E26 I Medium	800LM	7.5W	4.1" I 2.4"	2700K	83
LTA19F80030MB	Glass I Frosted	E26 I Medium	800LM	7.5W	4.1" I 2.4"	3000K	83
LTA19F80041MB	Glass I Frosted	E26 I Medium	800LM	7.5W	4.1" I 2.4"	4100K	83
LTA19S80024MB	Glass I Silver	E26 I Medium	800LM	7.5W	4.1" I 2.4"	2400K	83
LTA19S80027MB	Glass I Silver	E26 I Medium	800LM	7.5W	4.1" I 2.4"	2700K	83

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NOT USED

LOCHWOOD
WS83421

WALL

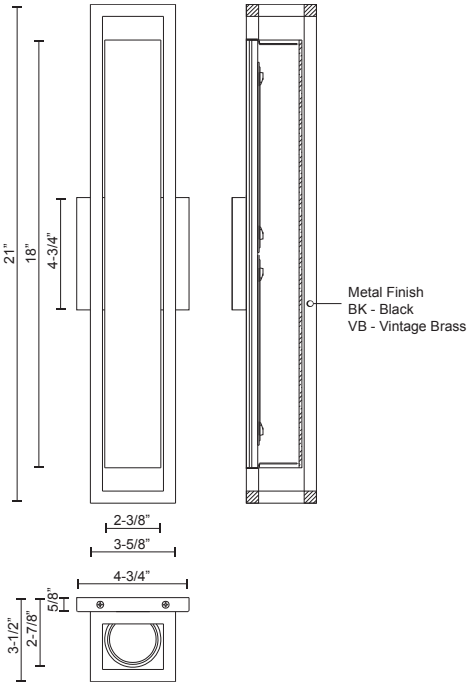
PROJECT

DESCRIPTION

Square powder-coated steel frame. Extruded aluminum heatsink mounted to square wall plate. Cylindrical opal glass diffuser. Outward emitting wall light. Custom options available.

WS83421-BK
Black

WS83421-VB
Vintage Brass



SPECIFICATION DETAILS

* For custom options, consult factory for details.

Fixture Dimensions	W3-5/8"x H21" x E3-1/2"
Light Source	LED
Wattage	21W
Total Lumens	1600lm
Delivered Lumens	VB-1180lm
Voltage	120V
Color Temperature	3000K
CRI (Ra)	>90
Optional Color Temps	2700K - 5000K Available, Minimum Order Quantities Apply
LED Rated Life	50,000 hours
Dimming	100% - 10%, ELV Dimmer (Not Included)
Glass Details	White Glass
Location	Dry
Warranty	5 Years
ADA Compliant	Yes
Canopy Dimensions	W4-3/4"x H4-3/4"x E5/8"

KUZCO

19054 28TH AVENUE
SURREY - BC V3Z 6M3
CANADA

WWW.KUZCOLIGHTING.COM

COMMENT

Intertek

EXISTING LUMINAIRE TO BE REFURBISHED

ARCHIPELAGO LIGHTING
Lighting | Reinvented

NOSTALGIC
A19
COMMERCIAL GRADE

FILAMENT LED
60 Watt
REPLACEMENT

USES ONLY 7.5W

- NATURAL DIMMING – DIM TO OFF[2]
- SUITABLE FOR WET LOCATIONS
- ENCLOSED RATED
- 25,000 HOURS RATED LIFE
- 3-YEAR LIMITED WARRANTY
- 360° LIGHT DISTRIBUTION
- ENERGY STAR LISTED[3]
- UL LISTED

ALSO AVAILABLE IN:


SILVER-TIP


FROSTED

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Model Number	Type	Base	Lumens	Wattage	MOL I MOD	CCT	CRI
LTA19C80024MB	Glass I Clear	E26 I Medium	800LM	7.5W	4.1" I 2.4"	2400K	83
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LTA19C80030MB	Glass I Clear	E26 I Medium	800LM	7.5W	4.1" I 2.4"	3000K	83
LTA19C80041MB	Glass I Clear	E26 I Medium	800LM	7.5W	4.1" I 2.4"	4100K	83
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ALSO AVAILABLE IN:


FROSTED


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SPEC SHEET

Logan Linear Tall Sconce

Item # TV1222AI

Designer: TOB by Thomas O'Brien

Specifications

Width: 4.75"
Height: 16.5"
Backplate: DP:0.625" W:4.75" H:16.5" OB UP:8.25" OB DOWN:8.25" Rectangular
Socket: 2 - Medium - T10
Rating: Damp Rated

Available Finishes

AI - Aged Iron
PN - Polished Nickel

circa LIGHTING®

ARCHIPELAGO LIGHTING
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HARPER

3643OZ-LED

LARGE SEMI-FLUSH MOUNT

Harper's sleek, retro design elevates the traditional flush mount with a unique opal glass bound by a prominent metal ring and decorative knobs available in four finishes.

DETAILS	
FINISH:	Oil Rubbed Bronze
MATERIAL:	Steel
GLASS:	Etched Opal

DIMENSIONS	
WIDTH:	18"
HEIGHT:	10"
WEIGHT:	8.5 lbs.

LIGHT SOURCE	
LIGHT SOURCE:	Integrated LED
LED NAME:	FSI-300
WATTAGE:	48w LED *Included
VOLTAGE:	120v
COLOR TEMP:	2700
LUMENS:	2850
CRI:	96
INCANDESCENT EQUIVALENCY:	3 x 100w
DIMMABLE:	Yes, on any Incandescent, MLV, ELV, or C-L dimmer.

MOUNTING	
CANOPY:	7" Dia.

SHIPPING	
CARTON LENGTH:	20"
CARTON WIDTH:	20"
CARTON HEIGHT:	14"
CARTON WEIGHT:	14.1 lbs.

PRODUCT DETAILS:

- Suitable for use in dry (indoor) locations as defined by NEC and CEC. Meets United States UL Underwriters Laboratories & CSA Canadian Standards Association Product Safety Standards
- Meets California Energy Commission 2016 Title regulations/JA8
- Equipped with a 120/277 universal driver. 0-10 dimming.
- LED components carry a 5-year limited warranty
- Merging the best of traditional and modern elements, with a sophisticated and streamlined silhouette perfect for any space
- Bold and robust dark bronze finish
- Please refer to Hinkley's Warranty for complete product warranty details; some warranty limitations may apply.

HINKLEY

HINKLEY
33000 Pin Oak Parkway
Avon Lake, OH 44012

PHONE: (440) 653-5500
Toll Free: 1 (800) 446-5539

hinkley.com

VOLTAIRE MINI ARCHITECTURAL WALL PACK

VWM

LED

VWMH-L10/830-TL-color per schedule-CGL-DRW/4565-DIM-UNV

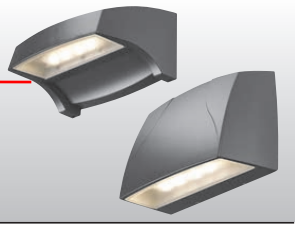
CATALOG #:

TYPE: C1

CAMPUS LED LIGHTING REPLACEMENT

PROJECT:

NOTES: *photocells shall be ordered & shipped separately

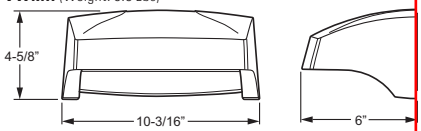


EXAMPLE: **VWM H - L20/740 - T3 - DBZ - SDGL - OPTIONS - DIM - UNV**

SERIES	TYPE	LUMEN PACKAGE	CRI & CCT	DISTRIBUTION	FINISH	SHIELDING	OPTIONS	DRIVER	VOLTAGE

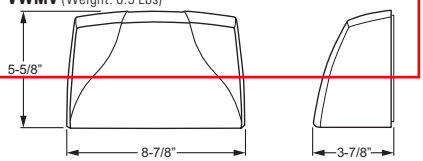
CROSS SECTIONS

VWMH (Weight: 6.5 Lbs)



Front view | Side View | Uplight Application

VWMV (Weight: 6.5 Lbs)



Front View | Side View | Uplight Application

ORDERING INFORMATION

SERIES

VWM	Voltaire Mini Architectural Wall Pack

TYPE

H	Horizontal
V	Vertical

LED PACKAGE

See back for fixture performance data.

Example: L17/740			
LUMEN PACKAGE	NOMINAL LUMENS	MINIMUM CRI & CCT	AVERAGE SYSTEM WATTAGE
L10	1,000	**830** =80 CRI, 3000K **840** = 80 CRI, 4000K **750** = 70 CRI, 5000K	13
L17	1,700		16
L20	2000	**730** =70 CRI, 3000K **740** = 70 CRI, 4000K **750** = 70 CRI, 5000K	25

DISTRIBUTION

TL	Lambertian distribution (L10 & L17 only)
T3	Type III (L20 only)

FINISH OPTIONS

For custom color, visit the VWM at hew.com.[1]

BLK	Black (RAL #9004)
DBZ	Dark bronze
DBR	Medium bronze
GRAY	Standard gray
SLV	Satin aluminum (RAL #9006)
WHT	White (RAL #9003)

SHIELDING

SDGL	Solite® diffused textured tempered glass lens
CGL	Clear tempered glass lens

OPTIONS

See back for option details.

PC	Factory-installed button-style photocell (120V, 208V, or 277V only; must specify voltage)
SP10	10kA/10kV surge protection

DRIVER

DIM	Dimming driver prewired for 0-10V controls

VOLTAGE

120	120V
208	208V
277	277V
UNV	120-277V

FEATURES

GENERAL

- Engineered with the highest quality materials to ensure reliability, performance, and quality.
- Provides security and accent lighting for walkways, entries, perimeters, and facades.
- Intended for use in both uplight and downlight applications.
- Aesthetically designed horizontal and vertical housings blend seamlessly with a variety of architectural styles.
- Purposefully modeled to allow runoff of dirt and water for an always-clean appearance.
- Optional energy-saving photocell available.
- Rated >50,000 hours at 70% lumen maintenance (L70).
- ANSI 3000K, 4000K, or 5000K CCT.
- Minimum 70 CRI.
- Available in six standard finish options.
- This fixture is proudly made in the USA.

THERMAL

- Integral die-cast aluminum heatsink provides optimal passive thermal management.
- Concealed heatsink design preserves architectural appearance.
- Rated ambient operating temperature -30°C to 50°C (L10, L17), -30°C to 45°C (L20).

OPTICAL

- Full cutoff, dark-sky compliant optics (downlight applications only) place light where it's needed with minimal glare.

ELECTRICAL

- 0-10V dimming standard.
- 10kA/10kV surge protection optional.

[1] For custom colors other than RAL, manufacturers' code plus two swatches (minimum 1" square) required.

VWM

VOLTAIRE MINI ARCHITECTURAL WALL PACK

LED

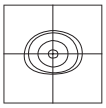
SPECIFICATIONS

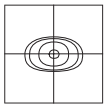
Housing – Die-cast aluminum enclosure.
Thermal Management – Integral die-cast aluminum heatsink and LED source provide passive thermal management. Rated ambient operating temperature -30°C to 50°C (L10, L17), -30°C to 45°C (L20).
Optical System – General output provides full cutoff.
LED Source – ANSI 3000K, 4000K, or 5000K CCT; 70 or 80 CRI LEDs. L20: circuit board design. L10 & L17: Chip on board.
LED Driver – 0-10V dimming.
Electrical – 120-277 VAC input range; 50-60Hz; power factor >.90; THD <20% at full load. FCC Class A compliant. Quick-disconnect wiring provided.
Finish – Super durable polyester powder coat bonded to phosphate-free, multi-stage pretreated metal, meets and exceeds AAMA 2604 specifications for outdoor durability. Available in six standard colors. Custom colors available.
Mounting – Surface mounts directly over a 4" maximum outlet box. Must be anchored to adequate structure that can safely support fixture weight (6.5 Lbs).
Labels – cCSAus certified as luminaire suitable for wet locations.
Certifications & Qualifications –

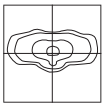
- Calculated L70 > 50,000 hours per IES TM-21.
- Tested to IES LM-79-08 standards.
- Lighting Facts listed.
- DLC qualified products listed at www.designlights.org.
- IDA Dark-Sky approved (downlight applications only).
- RoHS compliant.
- IP65 rated.
- Title 24 compliant with PC option.
- ADA compliant (VWMV only).
- BUG classified per IES TM-15-11.

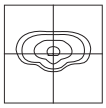
Warranty – 5-year limited warranty, see hew.com/warranty.

DISTRIBUTION DETAILS


VWMH TL


VWMV TL


VWMH/V T3
Clear Glass (CGL)


VWMH/V T3
Solite Glass (SDGL)

FIXTURE PERFORMANCE DATA

Series	Distribution	Lumen Package	Average System Wattage[1]	CCT	Clear Glass (CGL)		Solite Glass (SDGL		BUG Ratings
					Delivered Lumens [2 3]	Efficacy (lm/W) [2 3]	Delivered Lumens [2 3]	Efficacy (lm/W) [2 3]	
VWMH	TL	L10	13	3000	1188	91.3	1104	85.0	B1-U0-G0
				4000	1250	96.2	1163	89.4	
				5000	1349	103.8	1255	96.5	
		L17	16	3000	1644	102.8	1529	95.6	
				4000	1731	108.2	1610	100.6	
				5000	1840	115.0	1711	107.0	
	T3	L20	25	3000	2387	95.5	2197	87.9	B1-U0-G1
				4000	2390	95.6	2229	89.2	
				5000	2510	100.4	2341	93.6	
VWMV	TL	L10	13	3000	1006	77.4	936	72.0	B1-U0-G0
				4000	1059	81.5	985	75.8	
				5000	1201	92.4	1117	85.9	
		L17	16	3000	1520	95.0	1414	88.4	
				4000	1600	100.0	1488	93.0	
				5000	1704	106.5	1585	99.0	
	T3	L20	25	3000	2139	85.6	2022	80.9	B1-U0-G1
				4000	2290	91.6	2136	85.4	
				5000	2301	92.0	2146	85.8	

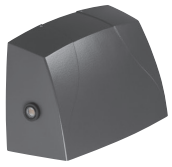
1 Wattage shown is average for 120V through 277V input.
2 Efficacy/lumen output shown is average based on voltage input of 120V through 277V.
3 Photometrics tested in accordance with IESNA LM-79. Results shown are based on 25°C ambient temperature.

LUMEN MAINTENANCE

Lumen Package	Ambient Temp.	Reported L70 Hours (TM-21)
L20	25°C	>60,000
	35°C	>60,000
	45°C	>60,000
L10/L17	25°C	>55,000
	35°C	>55,000
	45°C	>55,000

- Predicted lumen maintenance calculated from LED manufacturer IES LM-80 data and in-situ temperature measurement.
- Reported L70 hours in accordance with IES TM-21

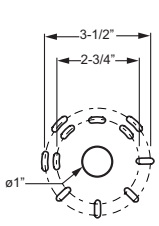
OPTIONS



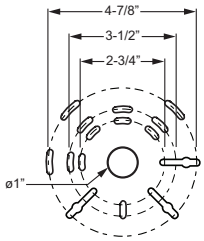
PC
Factory-installed button-style photocell
(120V, 208V, or 277V only; must specify voltage)

MOUNTING DETAILS

BOLT PATTERN DETAIL



VWPH



VWPV

BeveLED Mini® Complete - B3RD
3" Round Downlight

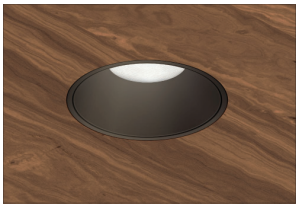
USAI Lighting

Universal and Field Convertible - Trim | Trimless | Millwork

Trimmed - B3RDF

Trimless - B3RDL

Millwork - B3RDM



Trimless Acoustical Tile - B3RDP

usailighting.com/beveledmini

To specify Trimless Acoustical Lighting visit usailighting.com/B3RDP

Introducing new and improved BeveLED Mini, the smallest member of our iconic BeveLED family. BeveLED Mini has been infused with upgraded performance for superior light in every application. Now available with the following features, by popular demand:

FEATURES

- Upgraded performance and more LED color options than ever before!
- Field Flexibility - it's now easy to change trim in the field between trimmed, trimless and millwork
- Dry/damp/wet location rated for bathrooms and showers, including trimless and millwork
- More dimming options and all color technologies available
- Clear overspray protector for installation convenience
- Full family platform
- Iconic beveled look

DOWNLIGHT PERFORMANCE DATA

LED COLOR CHOICES

DELIVERED* PERFORMANCE:	Classic White			Warm Glow Dimming		Color Select	
	9W	15W	20W	15W	20W	12W	18W
Source Lumens:	1175	1825	2475	1350	1800	925	1200
Lumens Per Watt:	102	102	97	68	66	65	57
Delivered Lumens:	925	1425	1950	1025	1375	775	1050

*Based on 3000K. Performance varies for each specific beamspread and color temperature. See IES files for exact values at usailighting.com.

CORRELATED COLOR TEMPERATURE MULTIPLIER	Classic White											
	2700K			3000K			3500K			4000K		
Color Rendering Index:	80+	90+	95+	80+	90+	95+	80+	90+	95+	80+	90+	95+
Multiplier for Lumen	0.96	0.81	0.70	1.00	0.86	0.74	1.03	0.88	0.79	1.06	0.81	0.81

	Warm Glow Dimming					Color Select						
	2700K		3000K		3500K	2200K	2700K	3000K	3500K	4000K	5000K	6000K
Color Rendering Index:	80+	90+	80+	90+	80+	80+	80+	80+	80+	80+	80+	80+
Multiplier for Lumen	1.00	0.78	1.00	0.83	1.05	0.92	0.97	1.00	1.03	1.05	1.10	1.13

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info@usailighting.com

BeveLED Mini® Complete - B3RD
3" Round Downlight with Integral Driver Housings

USAI Lighting

Specify fixture part number. (All boxes must be filled in to correctly order)

B3RD__

BeveLED Trim Style

F
Trimmed with Flange (use with all materials)

L
Trimless Spackle-in (use with sheetrock and plaster only)

M
Millwork Knife-Edge (use with wood and stone)

Wattage Options

Classic White Light

09X3
9W LED

15X3
15W LED

20X3
20W LED

Warm Glow Dimming

15WG2
15W LED

20WG2
20W LED

Color Select Tunable White

12CS1
12W LED

18CS1
18W LED (5)

LED Color Options

Classic White Light

27KS 2700K, 80+ CRI
27KH 2700K, 90+ CRI
27KU 2700K, 95+ CRI
30KS 3000K, 80+ CRI
30KH 3000K, 90+ CRI
30KU 3000K, 95+ CRI
35KS 3500K, 80+ CRI
35KH 3500K, 90+ CRI
35KU 3500K, 95+ CRI
40KS 4000K, 80+ CRI
40KH 4000K, 90+ CRI
40KU 4000K, 95+ CRI

Warm Glow Dimming

2722KS 2700K-2200K, 80+ CRI
2722KH 2700K-2200K, 90+ CRI
3022KS 3000K-2200K, 80+ CRI
3022KH 3000K-2200K, 90+ CRI
3522KS 3500K-2200K, 80+ CRI

Color Select Tunable White

6022KS 6000K-2200K, Tunable White Light 80+ CRI

Beam Options

Classic White Light

40 40° beam
55 55° beam
65 65° beam

Warm Glow Dimming

45 45° beam
55 55° beam
65 65° beam

Color Select Tunable White

45 45° beam
55 55° beam
65 65° beam

Lens Options

S
Solite (provided standard)

SF
Solite Frosted

BF
Borosilicate Frosted

Bevel Trim Finish Options

WH White
SC Conduit Silver
GR Grey
BL Black
BZ Bronze
PR Primer Finish
AC Clear Matte Anodized
AB Piano Gloss Black
RAL Custom Color Specify RAL #

*Flange/ Millwork Collar Finish

WH White
SC Conduit Silver
GR Grey
BL Black
BZ Bronze
PR Primer Finish
AC Clear Matte Anodized
WH White
BL Black
GR Grey
BZ Bronze
AB Piano Gloss Black
WH White
GR Grey
BL Black
BZ Bronze
RAL Custom Color Specify RAL #

*Leave blank for Trimless

Housing Options

FT
Flat Housing New Construction (1, 2)

FTIC
Flat Housing IC-Rated (up to 15W maximum) (1, 2)

FTA
Flat Adjustable Housing

NC1
New Construction All-in-One

NCCP
Chicago Plenum

NCIC
Insulation Contact Rated / Airtight

Voltage Options
Select one

UNV
120V-277V

120V

347V

Dimming Driver Options

For use with Universal Voltage 120V - 277V

No Additional Charge

D22
ERP 0-10V, 1% (2)

D6E
EldoLED 0-10V, 1% (4)

D6F
EldoLED 0-10V, 1% (4)

D4A
Lutron ECO, 0.1% (1, 2, 4)

D4E
Lutron 5 ECO, 5% (1, 2, 3, 4)

D4H
Lutron H ECO, 1% Fade (1, 2, 3, 4)

D4P
Lutron ECO, 1% (4)

D6A
EldoLED 0-10V, 0.1% (4)

D6B
EldoLED 0-10V, 0.1% (4)

D7
EldoLED DALI, 0.1% (4)

D18
Moons' DMX, 0.1% (2, 3, 4, 8)

For use with 120V only

No Additional Charge

D19
Phase 2-wire, 1% (1, 2)

D22
ERP Phase 2-wire, 1% (2)

D3
Lutron 2-wire, 1% (4, 6)

For use with 347V only

D15
0-10V dim, 1% 347V only (1, 2, 3, 4)

Accessories (Optional)*

CB27
27" C-Channel Bars

CB32
32" C-Channel Bars

CB52
52" C-Channel Bars

CM27
27" C-Channel Bars (use with FT and FTIC housings only)

CM52
52" C-Channel Bars (use with FT and FTIC housings only)

EM
Emergency Battery (7)

EMW
Emergency Battery Wet Location (7)

* Residential grade nailer bars provided standard

Notes:
1 Not available for Warm Glow.
2 Not available for Color Select
3 Not available with 9W
4 Not available with FT or FTIC housing
5 Not available with NCIC housing
6 Use only up to 15W max with NCIC housing
7 Not available with 347V. NC1 housing only. Requires above ceiling access for service
8 Not available in trimless and millwork

TRIM FINISH OPTIONS

White | Grey | Black | Bronze | Custom RAL (example) | Custom RAL (example)

Custom colors and primer finish also available

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BeveLED Mini® Complete - B3RD
3" Round Downlight with Remote Driver

USAI Lighting

1. Specify fixture part number. (All boxes must be filled in to correctly order)

B3RD__

BeveLED Trim Style

F Trimmed with Flange (use with all materials)

L Trimless Spackle-in (use with sheetrock and plaster only)

M Millwork Knife-Edge (use with wood and stone)

Wattage Options

Classic White Light

09X3 9W LED

15X3 15W LED

20X3 20W LED

Warm Glow Dimming

15WG2 15W LED

20WG2 20W LED

LED Color Options

27KS 2700K, 80+ CRI

27KH 2700K, 90+ CRI

27KU 2700K, 95+ CRI

30KS 3000K, 80+ CRI

30KH 3000K, 90+ CRI

30KU 3000K, 95+ CRI

35KS 3500K, 80+ CRI

35KH 3500K, 90+ CRI

35KU 3500K, 95+ CRI

40KS 4000K, 80+ CRI

40KH 4000K, 90+ CRI

40KU 4000K, 95+ CRI

2722KS 2700K-2200K, 80+ CRI

2722KH 2700K-2200K, 90+ CRI

3022KS 3000K-2200K, 80+ CRI

3022KH 3000K-2200K, 90+ CRI

3522KS 3500K-2200K, 80+ CRI

Beam Options

40 40° beam

55 55° beam

65 65° beam

45 45° beam

55 55° beam

65 65° beam

Lens Options

S Solite (provided standard)

SF Solite Frosted

BF Borosilicate Frosted

Bevel Trim Finish Options

WH White

SC Conduit Silver

GR Grey

BL Black

BZ Bronze

PR Primer Finish

AC Clear Matte Anodized

AB Piano Gloss Black

RAL Custom Color Specify RAL #

*Flange/ Millwork Collar Finish

WH White

SC Conduit Silver

GR Grey

BL Black

BZ Bronze

PR Primer Finish

AC Clear Matte Anodized

WH White

BL Black

GR Grey

BZ Bronze

AB Piano Gloss Black

WH White

GR Grey

BL Black

BZ Bronze

RAL Custom Color Specify RAL #

*Leave blank for Trimless

Housing Options

FT Flat Housing New Construction

FTIC Flat Housing IC-Rated (up to 15W maximum)

FTA Flat Adjustable Housing

NC1 New Construction All-in-One

NCCP Chicago Plenum

NCIC Insulation Contact Rated / Airtight

RM

Remote Dimming Driver

RM Remote Dimming Driver, specify remote power supply in table below

Accessories (Optional)

CB27 27" C-Channel Bars

CB32 32" C-Channel Bars

CB52 52" C-Channel Bars

CM27 27" C-Channel Bars (use with FT and FTIC housings only)

CM52 52" C-Channel Bars (use with FT and FTIC housings only)

* Residential grade nailer bars provided standard

USAI Power Supply Must Be Specified

2. Specify Remote Power Supply

RPB-01

Remote Power Supply

RPB-01 BeveLED Mini Remote Power Supply

Wattage Options

Classic White

09X3 9W LED

15X3 15W LED

20X3 20W LED

Warm Glow

15WG2 15W LED

20WG2 20W LED

Voltage

UNV 120V - 277V

120V 120V Only

Remote Dimming Type and Level

D4A Lutron ECO, 0.1% (1)

D4E Lutron 5 ECO, 5% (1, 2)

D4H Lutron H ECO, 1% Fade (1, 2)

D4P Lutron ECO, 1%

D6A EldoLED 0-10V, 0.1%

D6B EldoLED 0-10V, 0.1%

D6E EldoLED 0-10V, 1%

D6F EldoLED 0-10V, 1%

D7 EldoLED DALI, 0.1%

D18 Moons DMX, 0.1% (2)

D3 Lutron 2-wire, 1%

D19 Hatch Phase 2-wire, 1% (1)

1 Not available for Warm Glow 2 Not available for 9W

Remote Emergency Option

EM7 EM battery requires remote enclosure by others, minimum size 14.5" L x 6.5" W x 3" H

NOTE:
Remote Power Supplies Require Enclosures by Others.
See Page 6 for Details.

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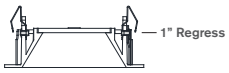
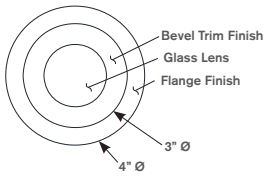
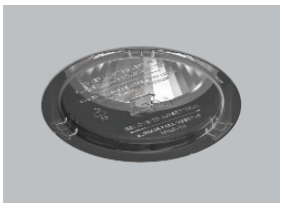
Trimmed - B3RDF

TRIM DETAILS

Trimmed - B3RDF



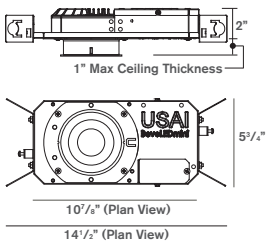




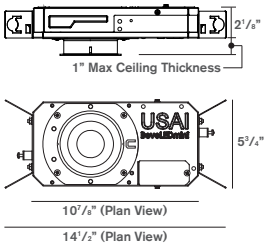
Clear acrylic overspray protector provided standard with every housing to keep out dust and contaminants during construction. Allows for use as work light.

HOUSING OPTIONS

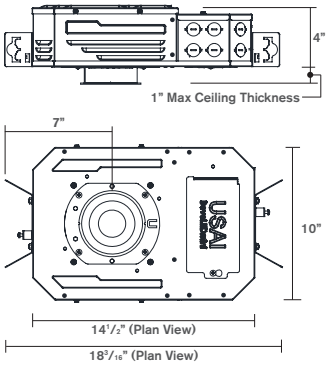
Flat Housing - FT



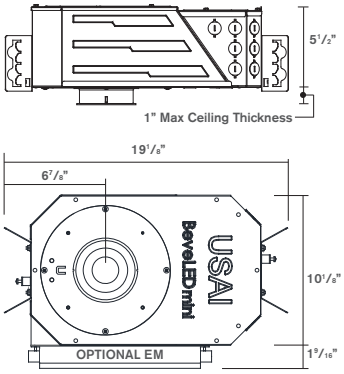
Flat Housing, IC-Rated - FTIC
(up to 15W maximum)



Flat Adjustable Housing - FTA



New Construction Housing - NC1
Insulation-Contact Rated - NCIC
Chicago Plenum Rated - NCCP



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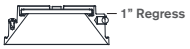
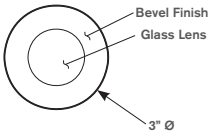
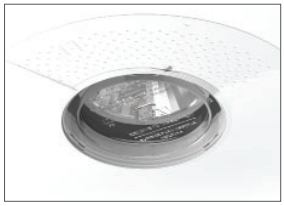
Trimless - B3RDL

TRIM DETAILS

Trimless - B3RDL



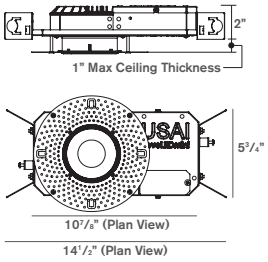




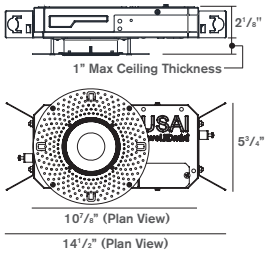
Clear acrylic overspray protector provided standard with every housing to keep out dust and contaminants during construction. Allows for use as work light.

HOUSING OPTIONS

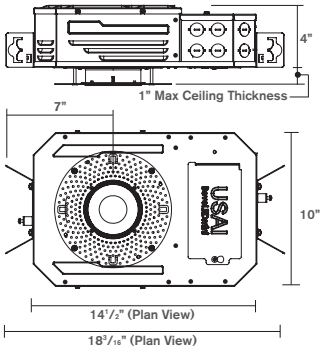
Flat Housing - FT



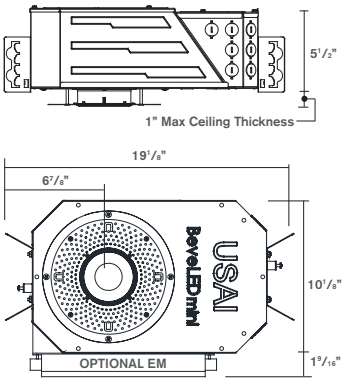
Flat Housing, IC-Rated - FTIC
(up to 15W maximum)



Flat Adjustable Housing - FTA



New Construction Housing - NC1
Insulation-Contact Rated - NCIC
Chicago Plenum Rated - NCCP



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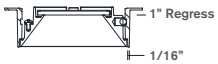
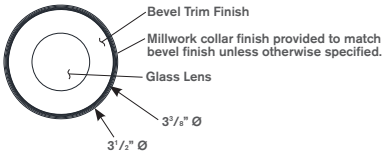
Millwork - B3RDM

TRIM DETAILS

Millwork - B3RAM

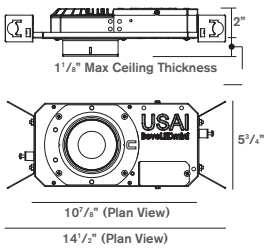




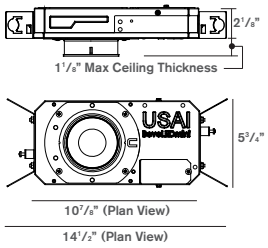
Clear acrylic overspray protector provided standard with every housing to keep out dust and contaminants during construction. Allows for use as work light.

HOUSING OPTIONS

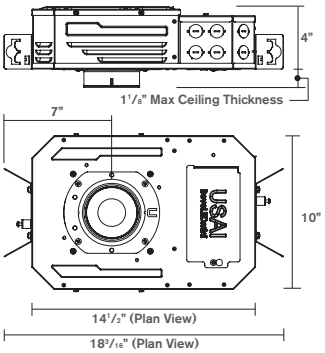
Flat Housing - FT



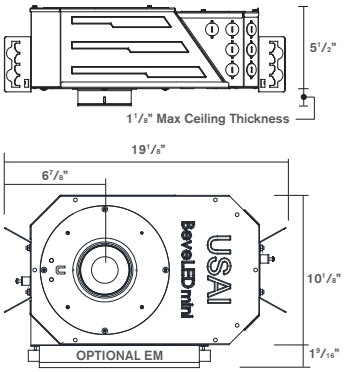
Flat Housing, IC-Rated - FTIC
(up to 15W maximum)



Flat Adjustable Housing - FTA



New Construction Housing - NC1
Insulation-Contact Rated - NCIC
Chicago Plenum Rated - NCCP



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BeveLED Mini® Complete - B3RD
3" Round Downlight

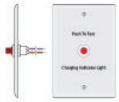
USAI® Lighting

BEVELED MINI SPECIFICATIONS

FIELD REPLACEABLE LED LIGHT ENGINE
is serviceable through the aperture with a Phillips screwdriver. All USAI Lighting light engines feature industry-leading color consistency.

FIELD REPLACEABLE INTEGRAL DRIVER
Unless otherwise specified, a 0-10V, 100%-1% solid state electronic constant current integral D22 dimming driver with a high power factor is provided standard and sources 2mA. All integral dimming drivers are located within the fixture housing and are serviceable from below the ceiling through the aperture. Some on-time delay may be experienced depending on control system used. All dimming drivers comply with IEEE C62.41 surge protection.

INTEGRAL EMERGENCY BATTERY
An integral emergency battery pack is available as an option with the NC1 housing and integral driver/power supply only. IOTA emergency battery provides backup power for 90 minutes. NC1 fixtures are provided with an integral emergency battery that requires above ceiling access for service, and a remote test switch, which comes with a 24" lead length for location of the test switch. Remote EM test switch is dry/damp only; select EMW emergency option for a wet location-rated EM test switch. Fixtures that have no USAI EM option may be connected to an inverter (by others) for emergency lighting. Battery is not available with 347V.



Remote Emergency Test Switch included with NC1 housing and integral driver only. Above ceiling access required for service.

REMOTE LOCATION DRIVER
BeveLED Mini is available for use with remotely located driver. Driver is provided separately for remote location on site, enclosure to be provided by others. Remote dimming driver power supply option must be clearly specified in the "RP" table. Remote power supplies require enclosures by others that meet local codes and must be located in an accessible service panel within 100ft of the light fixture; see remote driver table below for coordination of enclosure sizes and wire gauges required. All dimming drivers comply with IEEE C62.41 surge protection.

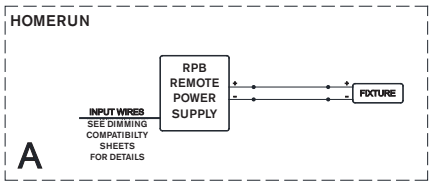
Remote Power Supply Requirements and Wiring Diagram
enclosure sizes and wire gauge with **1 fixture** per power supply.

Remote Power Supply	Dimming Option		Wire Gauge Required*	Minimum Enclosure Size Required (by others) RP Only	RP with EM Option**
RPB-01-09X3 RPB-01-15X3 RPB-01-20X3 RPB-01-15WG2 RPB-01-20WG2	**UNV-D4A**	Lutron ECO, 0.1% (1)	14/12	6.25" W x 4" L x 2" H	14.5" W x 6.5" L x 3" H
	UNV-D4E	Lutron 5 ECO, 5% (1, 2)			
	UNV-D4H	Lutron H ECO, 1% fade (1, 2)			
	UNV-D4P	Lutron ECO, 1%			
	UNV-D6A	EldoLED 0-10V, 0.1%	18/16		
	UNV-D6B	EldoLED 0-10V, 0.1%			
	UNV-D6E	EldoLED 0-10V, 1%			
	UNV-D6F	EldoLED 0-10V, 1%			
	UNV-D7	EldoLED DALI, 0.1%			
	UNV-D18	Moons DMX, 0.1% (2)			
	120V-D3	Lutron 2-wire phase, 1%	14/12	5.75" W X 2.625" L x 2" H	
	120V-D19	Hatch 2-wire phase, 1% (1)	14/12		

1 Not available for Warm Glow
2 Not available for 9W

Not all dimming options are availbale with all LED light engine options. See RP ordering table for details.
* Wire gauge 14/12 = Maximum distance from light fixture to remote power supply is 100' using 12 gauge wire, 50' using 14 gauge wire.
* Wire gauge 18/16 = Maximum distance from light fixture to remote power supply is 100' using 16 gauge wire, 50' using 18 gauge wire.
** Emergency battery remote power supplies cannot be located any more than 50 feet from light fixture.

Note: All light fixtures must be wired in homeruns per wiring diagram below.



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BeveLED Mini® Complete - B3RD
3" Round Downlight

USAI® Lighting

BEVELED MINI SPECIFICATIONS

HOUSING
All BeveLED Mini fixtures are field-flexible which allows for field changes from trimless or millwork to trimmed with a simple components change with parts from USAI. Housings are fabricated of 20 ga. steel construction with thru wire J-box, 4 in 4 out at min. 90°C, #12 AWG thru branch circuit wiring. FTIC and NCIC housing for use with 9W, 12W, and 15W light engines only are rated for direct contact with spray foam insulation of R-42 or less. FTIC housing is IC-rated up to 15W maximum.

MOUNTING
B3RDF overlap flange fixtures are designed for use in sheetrock, acoustical ceiling tile, and many other ceiling materials. B3RDL trimless fixtures are provided with a spackle collar and are designed for use in sheetrock/mud-in ceiling applications. B3RDM millwork fixtures are provided with a millwork collar and are designed for use in wood/millwork and stone construction applications. Butterfly brackets and residential grade adjustable nailer bars extendible from 14" to 24" centers with integral nails are provided standard for attachment to building structure. C-channel bars are optionally available for acoustical ceiling applications. If channel bars are specified for FT or FTIC housing, special reduced height channel bars (CM27 or CM52) will be provided.

Residential-grade nailer bars provided standard.

FIXTURE WEIGHT
FT and FTIC housings weigh 4 lbs. FTA housing weighs 10 lbs. NC1, NCIC, and NCCP housings weigh 11 lbs. NC1 housing with EM weighs 14 lbs.

WARRANTY
Based on IESNA LM80-2008, BeveLED has a 50,000 hour rated life at 70% lumen maintenance (L70). USAI Lighting Warranty covers replacement parts for 5 years from date of shipment. Ambient temperatures at fixture location should not exceed 40°C during normal operation.

CEILING CUT OUT
B3RDF Trimmed with Overlap Flange: 3-5/8"Ø
B3RDL Trimless Spackle-in: 4-3/16"Ø
B3RDM Millwork Knife-edge: 3-9/16"Ø

LISTINGS
Dry/Damp/Wet location. AC and AB trim finishes are dry/damp only. EM test switch is dry/damp only. Select EMW option for wet location remote test switch. UL2043 rated for use in air handling plenums. NRTL/CSA-US tested to UL standards. IBEW union made.

NOTES
- Not for use in corrosive environment
- Use of pressure washer voids warranty

PHOTOMETRICS
Consult factory or website for IES files. Tested in accordance with IESNA LM79.

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BeveLED Mini® Complete - B3RD
3" Round Downlight

USAI® Lighting

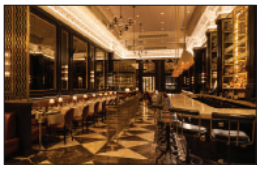
LED COLOR OPTIONS

Classic White Light

Our proprietary LED light engines achieve a 2-step MacAdam ellipse along the black body locus, resulting in reliable and uniform color from fixture to fixture. You'll see the results in consistently beautiful light throughout your space, whichever USAI LED product you specify.


Warm Glow® Dimming

Warm Glow Dimming provides warmth and glow once possible only in dimmed incandescent sources. Utilizing our patented proprietary algorithm and circuitry, Warm Glow Dimming technologies precisely mimic the black body curve of a standard 100W A19 lamp by gradually transitioning from 2700K , 3000K or 3500K down to 2200K. The result is virtually indistinguishable from an incandescent light source.

Color Select® Tunable White

Color Select represents the next innovation in color temperature control for advanced LED recessed downlighting. Color Select® products allow users to adjust color temperature from 6000K down to 2200K while independently adjusting intensity to achieve ultimate control over the quality of light in a space with a single fixture type. Color Select interfaces with standard dimming and control systems.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USAI Lighting

DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D3 / DIML3

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

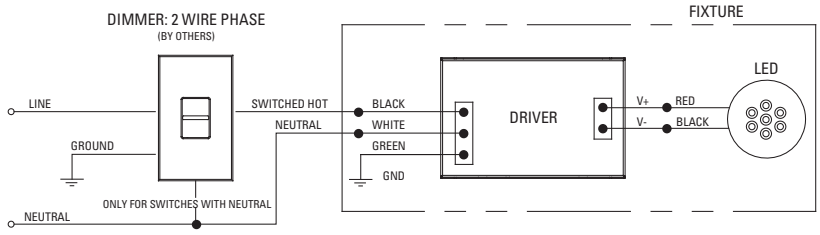
D3 / DIML3 LED: Lutron Hi-Lume A-Series 2 Wire Fwd Phase (with neutral) / LED Dimming Driver Wiring (Dims down to 1%) 120V

D3 / DIML3 Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Dimmer* Fixture Wattage	
120V Only				39W and Less	40W - 80W
ETC	Sensor+ Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
ETC	Unison DRd Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
Lutron	Maestro Wireless® 600W dimmer	MRF2-6ND-120-	100% - 1%	1 – 8	1 – 4
Lutron	Maestro Wireless® 1000W dimmer	MRF2-10ND-120-	100% - 1%	1 – 13	1 – 6
Lutron	HomeWorks® QS adaptive dimmer	HQRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 600W dimmer	HQRD-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 1000 W dimmer	HQRD-10ND-	100% - 1%	1 – 13	1 – 6
Lutron	Caseta Wireless® Pro 1000W dimmer	PD-10NXD-	100% - 1%	1 – 13	1 – 6
Lutron	Stanza® dimmer	SZ-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 adaptive dimmer	RRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 1000 W dimmer	RRD-10ND-	100% - 1%	1 – 6	1 – 3
Lutron	myRoom DIN power module	MQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® QS wallbox power module	HQRJ-WPM-6D-120-	100% - 1%	1 – 26	1 – 13
Lutron	Homeworks® DIN power module	LQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® wallbox power module	HWI-WPM-6D-120	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® QS control unit	QSGR-, QSGRJ-	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® 3000 control unit	GRX-3100-, GRX-3500-	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4U module	HW-RPM-4U-120, LP-RPM-4U-120	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4A module	HW-RPM-4A-120, LP-RPM-4A-120	100% - 1%	1 – 26	1 – 13
Lutron	GP dimming panels	Various	100% - 1%	1 – 26	1 – 13
Lutron	Ariadni CL 250W dimmer	AYCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Diva CL 250W dimmer	DVCL-253P-, DVSCCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Grafik T CL or RF CL dimmer	GT-250M-, GTJ-250M-	100%-1%	1 – 8	1 – 4
Lutron	Nova T CL 250W dimmer	NTCL-250-	100%-1%	1 – 10	1 – 5

* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D3 / DIML3
2 WIRE PHASE DIMMING



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I2-264-3 Revised 03/22/2017

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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D4A / DIML4A and D4P / DIML4P

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

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4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

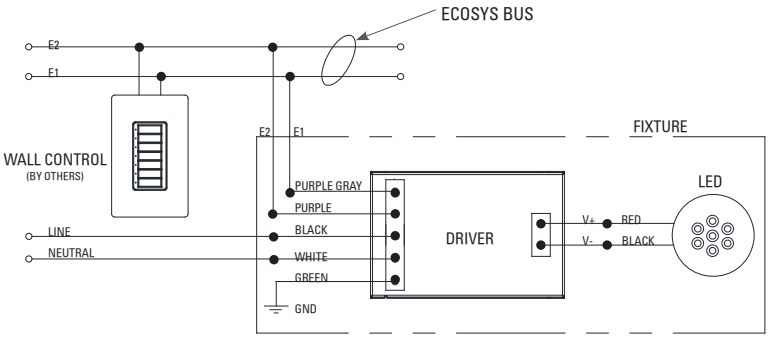
D4A / DIML4A LED: Lutron Hi-Lume Premier EcoSystem LED Driver (Dims down to 0.1%)
D4P / DIML4P LED: Lutron Hi-Lume Premier EcoSystem LED Driver (Dims down to 1%)

D4A / D4P EcoSystem Controls Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Maximum Quantity Light Fixtures Per Control
120V / 277V			
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	32
		FCJ/FCJS-ECO	3
120V ONLY			
Lutron	Energi Savr Node	QSN-1ECO-S	64
		QSN-2ECO-S	128
	GRAFIK Eye QS/ Homeworks QS control unit	QSGRJ-_ E, QSGR-_ E	64
	Quantum Hub	QP2-__2C	128
		QP2-__4C	256
		QP2-__6C	384
		QP2-__8C	512
	HomeWorks QS / myRoom Plus power module	LQSE-2ECO-D	128

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D4A / DIML4A and D4P / DIML4P
EcoSystem CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D4E / DIML4E and D4H /DIML4H

DIMMING DRIVER WIRING SCHEMES:

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4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D4E / DIML4E LED: Lutron 5 Series EcoSystem LED Driver / LED Dimming Driver Wiring (Dims down to 5%)

D4E / DIML4E EcoSystem Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V / 277V				39W and Less	40W - 80W
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	100%–5%	1–32	1–16
Lutron	Energi Savr Node	QSN-1ECO-S, QSN-2ECO-S	100%–5%	1–64	1–32
Lutron	GRAFIK Eye QS (120V ONLY)	QSGRJ- E, QSGR- E	100%–5%	1–64	1–32
Lutron	Quantum	Various	100%–5%	1–64	1–32

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

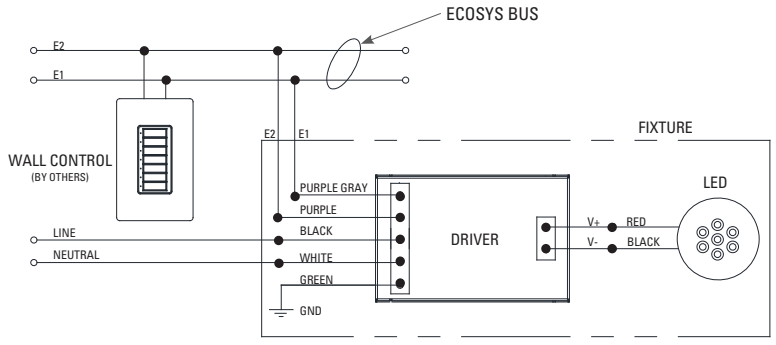
D4H / DIML4H LED: Lutron H Series EcoSystem LED Driver with Fade to Black (dims down to 1%)

D4H / DIML4H EcoSystem Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V / 277V				39W and Less	40W - 80W
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	100%–1%	1–32	1–16
Lutron	Energi Savr Node	QSN-1ECO-S, QSN-2ECO-S	100%–1%	1–64	1–32
Lutron	GRAFIK Eye QS (120V ONLY)	QSGRJ- E, QSGR- E	100%–1%	1–64	1–32
Lutron	Quantum	Various	100%–1%	1–64	1–32

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D4E / DIML4E and D4H / DIML 4H EcoSystem CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D6A / DIML6A and D6E / DIML6E
D6B / DIML6B and D6F / DIML6F

IMPORTANT SAFETY INSTRUCTIONS
- SAVE THESE INSTRUCTIONS

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3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D6A / DIML6A and D6E / DIML6E LED Dimming Compatibility Table

D6A / DIML6A and D6E / DIML6E are linearly programmed dimming drivers for use with the dimming controls listed in the table below.
D6A / DIML6A = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1%
D6E / DIML6E = EldoLED ECOdrive 0-10V control dims from 100% to 1%

D6A / DIML6A and D6E / DIML6E Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range			Qty Fixtures Per Dimmer*
120V & 277V			DIML6A		6E	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Lutron	Diva	DVTV/NFTV with PP-20	99% -	0.1%	1%	
Lutron	Nova T	NTFTV with PP-20	99% -	0.1%	1%	
Lutron	Energi Savr Node	QSN-4T16-S	100% -	0.1%	1%	
Lutron	GP Dimming Panels	TVM2 Module	99% -	0.1%	1%	
Lutron	Interfaces	GRX-TVI w/ GRX3503	100% -	0.1%	1%	
Sensor Switch	nIO	nIO EZ	100% -	0.1%	1%	
enlighted	Control Unit	CU-3E-1R	100% -	0.1%	1%	

D6B / DIML6B and D6F / DIML6F LED Dimming Compatibility Table

D6B / DIML6B and D6F / DIML6F are logarithmic-programmed dimming drivers for use with the dimming controls listed in the table below.
D6B / DIML6B = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1% D6F / DIML6F = EldoLED ECOdrive 0-10V control dims from 100% to 1%

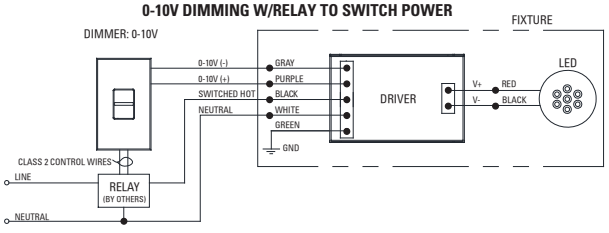
D6B / DIML6B and D6F / DIML6F Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range			Qty Fixtures Per Dimmer*
120V & 277V			DIML6B		6F	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Bush-Jaeger	Electronic potentiometer	2112U-101	100% -	0.1%	1%	
Jung	Electronic potentiometer	240-10	100% -	0.1%	1%	
Leviton	Iluma Tech dimmer	IP710-DLX	100% -	0.1%	1%	
Lightolier (Philips)	Momentum (120V ONLY)	ZP600FAM120	100% -	0.1%	1%	
Merten	Electronic potentiometer	5729	100% -	0.1%	1%	
Pass & Seymour	Titan	CD4FB-W	100% -	0.1%	1%	
Watt Stopper	Miro	DCLV1	100% -	0.1%	1%	
Synergy	Wallbox Dimmers	ISD BC	100% -	0.1%	1%	
ABB	i-bus	SD/S 2.16.1	100% -	0.1%	1%	
Crestron	Modules	GLX-DIMFLV8, GLXP-DIMFLV8	100% -	0.1%	1%	
Crestron	Green Light	GLPAC-DIMFLV4-, GLPAC-DIMFLV8-	100% -	0.1%	1%	
Crestron	Green Light Power Pack	GLPP-DIMFLVEX-PM, GLPP-1DIMFLV2EX-PM, GLPP-1DIMFLV3EX-PM	100% -	0.1%	1%	
Crestron	DIN Rail Analog Output Module	DIN-A08	100% -	0.1%	1%	
Crestron	DIN Rail 0-10V Fluorescent Dimmer	DIN-4DIMFLV4	100% -	0.1%	1%	
Crestron	iLux 0-10V Dimmer Expansion Module	CLS-EXP-DIMFLV	100% -	0.1%	1%	
enlighted	Control Unit	CU-3E-1R	100% -	0.1%	1%	

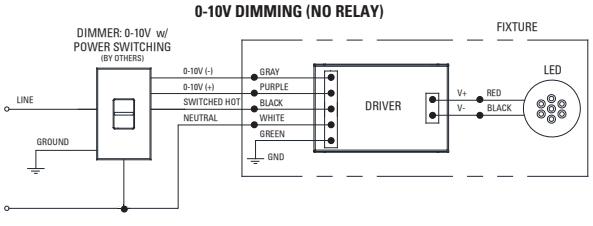
DIMMING DRIVER WIRING SCHEMES:

NOTES: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

D6 / DIML6
0-10V DIMMING W/RELAY TO SWITCH POWER



D6 / DIML6
0-10V DIMMING (NO RELAY)



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CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D7 / DIML7 and D7E

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

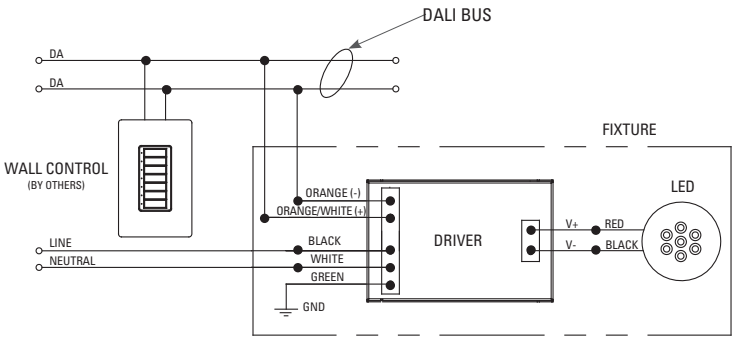
IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D7 / DIML7 and D7E Dimming Driver Wiring

D7 / DIML7 and D7E are linearly programmed dimming drivers.
D7 / DIML7 = EldoLED SOLOdrive DALI control dims from 100% to 0.1%
D7E = EldoLED ECOdrive DALI control dims from 100% to 1%

D7 / DIML7 / D7E
DALI CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D15 / DIML15

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

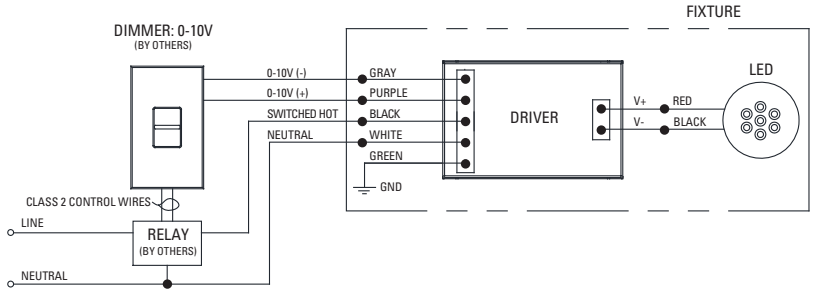
D15 / DIML15 LED: 0-10V, 347V Dimming Driver Wiring (Dims down to 1%) 347V Only

D15 / DIML15 Dimmer Compatibility Chart

Manufacturer	Product	Dimmed Light Output Range	Qty Fixtures Per Dimmer*
347			Use source current per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
Acuity	Synergy ISD-BC	100% - 1%	
Douglas Lighting	WPN-5721, WPN-5822	100% - 1%	
Hubbell	Light Hawk2 LHD-IRS3-N347-xx	100% - 1%	
Leviton	Illumatech IP710-DLZ with 347V relay	100% - 1%	
Leviton	Centura Fluorescent Control System	100% - 1%	
Lutron	Nova NFTV-* dimmer plus 347V relay	100% - 1%	
Lutron	Diva DVTV-* dimmer plus 347V relay	100% - 1%	

* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D15 / DIML15
0-10V DIMMING W/RELAY TO SWITCH POWER



NOTE:
If switched, non-dimming operation is desired, cap off purple and gray wires individually at installation. Do NOT cap purple and gray wires together.

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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D18

DIMMING DRIVER WIRING SCHEMES:

NOTES:

Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D18 Dimming Driver Wiring

D18 are programmed dimming drivers.
D18 Moons DMX control dims from 100% to 1%

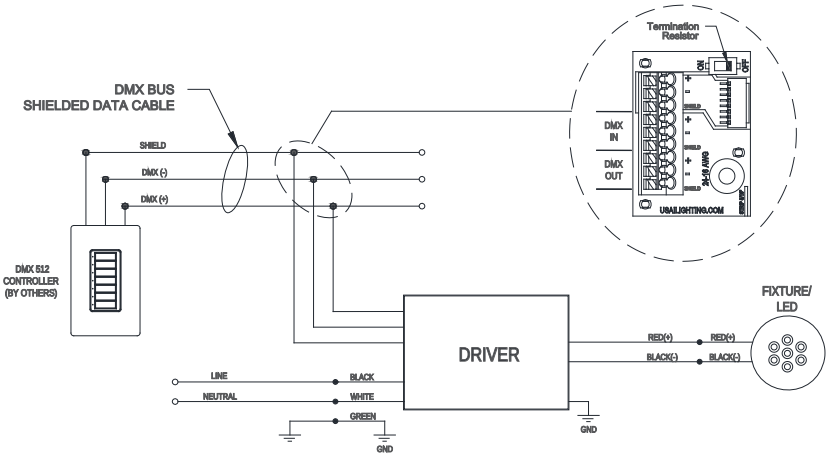
DMX BUS -
SHIELDED DATA CABLE

The data cable used must meet the following requirements:

- type: shielded, 2-conductor twisted pair
- maximum capacitance between conductors: 30 pF/ft
- maximum capacitance between conductor and shield: 55 pF/ft
- maximum resistance: 0.02 ohms/ft
- normal impedance: 100-140 ohms
- conductive core: 24 AWG is recommended

If 3-wire data cables are preferred, we suggest a Belden 9841 or equivalent cable which meets the specifications for EIA RS-485 applications. Do not use standard microphone cables: they cannot transmit DMX512 data reliably over long distances. NOTE: DMX link termination device, provided through Dip Switch on connection board, should be used on last fixture in line on a circuit to avoid signal loss.

D18
DMX CONTROLS



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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D19 / DIML19

DIMMING DRIVER WIRING SCHEMES:

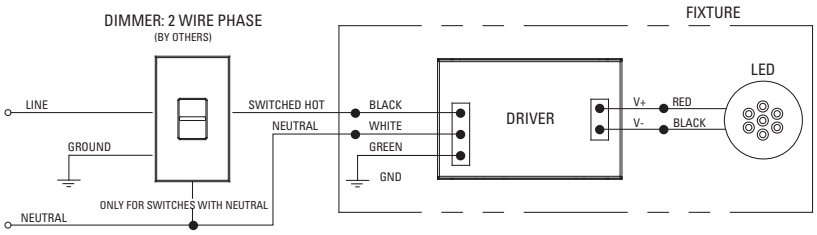
NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D19 / DIML19 LED: Hatch XTC series or equivalent - Forward and Reverse Phase Dimming Driver. Dims down to 1% contingent upon dimmer specification and load. 120V only.

D19 / DIML19
2 WIRE PHASE DIMMING



D19 / DIML19 Dimmer Compatibility Chart

120V ONLY		
Forward Phase / TRIAC Dimming		
Manufacturer	Product	Qty Fixtures Per Dimmer
Leviton	IPL06-10Z	Use fixture wattage per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
	6613-xxx	
Lutron	S-600P	
	S-603P	
	DV-600P	
	DV-603P	
	DVSC-603P	
	CT-600P	
	CT-603P	

120V ONLY		
Reverse Phase / ELV Dimming		
Manufacturer	Product	Qty Fixtures Per Dimmer
Leviton	6615	Use fixture wattage per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
	IPE04-xxx	
Lutron	NTELV-300	
	NTELV-600	
	SELV-300P	
	SELV-303P	
	DVELV-300P	
	DVELV-303P	

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DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
D22

DIMMING DRIVER WIRING SCHEMES:

NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

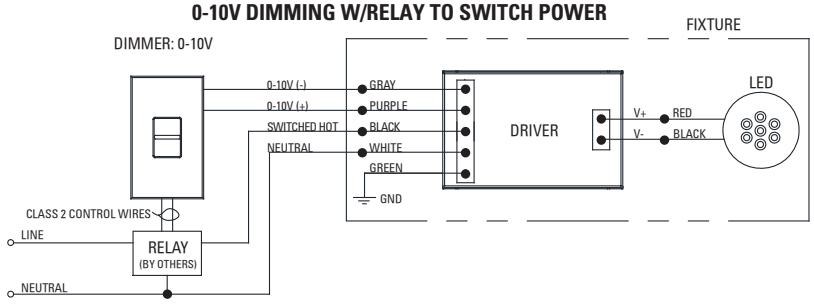
D22 LED: ERP ESS 0-10V Dimming Driver Wiring (Dims down to 1%)

D22 Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Dimmer*
120V / 277V				Use source current per fixture specification sheet to determine number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating.
Crestron	iLux dimmer expansion module	CLS-EXP-DIMFLV	100% - 1%	
Crestron	DIN Rail dimmer	DIN-4DIMFLV4	100% - 1%	
Crestron	DIN Rail analog output module	DIN-A08	100% - 1%	
Crestron	8 Channel dimmer module	GLX-DIMFLV8	100% - 1%	
Crestron	8 Channel dimmer module	GLXP-DIMFLV8	100% - 1%	
Leviton	IllumaTech dimmer	IP710-DLX	100% - 1%	
Lutron	Nova T	NFTV-XX	100% - 1%	
Lutron	Diva	DVTV-XX	100% - 1%	

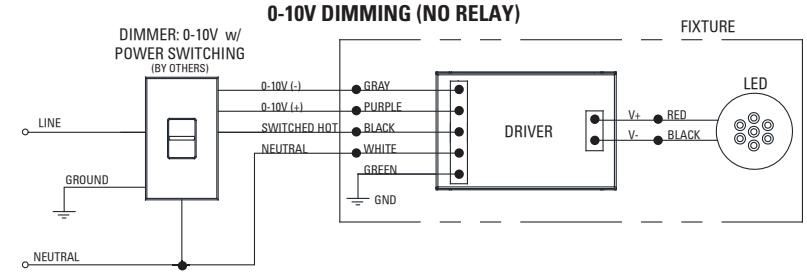
* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

D22
0-10V DIMMING W/RELAY TO SWITCH POWER



NOTE:
If switched, non-dimming operation is desired, cap off purple and gray wires individually at installation. Do NOT cap purple and gray wires together.

D22
0-10V DIMMING (NO RELAY)



NOTE:
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DIMMING DRIVER WIRING SCHEMES:

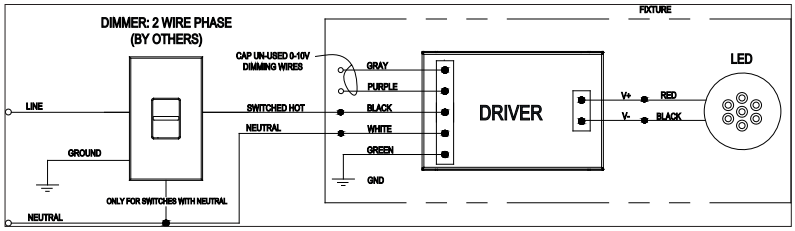
NOTES:
Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS

1. Keep these instructions in a safe place for future reference.
2. Only qualified electricians in accordance to local codes should install these fixtures.
3. De-energize the electrical circuit at the circuit breaker prior to installation process or servicing.
4. Make sure all connections are in accordance with the National Electrical Code and any local regulations.
5. Cap any wires not used separately (not together).

D22 LED: ERP ESS series or equivalent - Forward and Reverse Phase Dimming Driver.
Dims down to 1% contingent upon dimmer specification and load (see compatibility chart below). 120V only.

D22
2 WIRE PHASE DIMMING



D22 Dimmer Compatibility Chart

120V ONLY PHASE DIMMING				
Dimmer Information		Dimming Range		Qty Fixtures
Manufacturer	Product	Maximum	Minimum	Per Dimmer
Cooper	DAL06P	100%	0%	Use fixture wattage per fixture specification sheet to determine maximum number of fixtures per dimmer. Max number of fixtures is limited by dimmer load rating per dimmer specification sheet.
	DLC03P	100%	0%	
	SLC03P	100%	0%	
Leviton	6161	99%	10%	
	6631-2	100%	0%	
	6633-P	100%	0%	
	6673-10W	99%	6%	
	6683-IW	100%	2%	
	IPE04	100%	3%	
	IPI06-1LZ	99%	0%	
	VPE06	100%	5%	
Lightolier	ZP260QEW	99%	3%	
Lutron	CT103P	99%	6%	
	DV600P	99%	3%	
	DVCL-153P	99%	0%	
	DVELV303P	97%	3%	
	FAELV500	99%	7%	
	LG600P	99%	5%	
	MAELV600	99%	7%	
	S600P	99%	1%	
	S-603PG	86%	4%	
	SELV300P	97%	3%	
	TG-600P	99%	13%	
	TGCL-153P	99%	2%	

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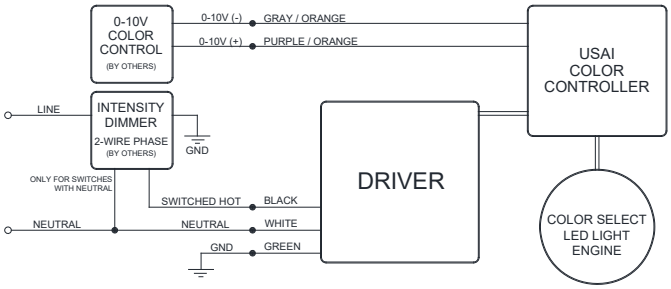
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML3

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML3 LED: Lutron Hi-Lume A-Series 2 Wire Fwd Phase (with neutral) / LED Dimming Driver Wiring (Dims down to 1%) 120V only.



D3 / DIML3 Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Dimmer* Fixture Wattage	
120V Only				39W and Less	40W - 80W
ETC	Sensor+ Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
ETC	Unison DRd Cabinet	ELV10	100% - 1%	1 – 26	1 – 13
Lutron	Maestro Wireless® 600W dimmer	MRF2-6ND-120-	100% - 1%	1 – 8	1 – 4
Lutron	Maestro Wireless® 1000W dimmer	MRF2-10ND-120-	100% - 1%	1 – 13	1 – 6
Lutron	HomeWorks® QS adaptive dimmer	HQRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 600W dimmer	HQRD-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	HomeWorks® QS 1000 W dimmer	HQRD-10ND-	100% - 1%	1 – 13	1 – 6
Lutron	Caseta Wireless® Pro 1000W dimmer	PD-10NXD-	100% - 1%	1 – 13	1 – 6
Lutron	Stanza® dimmer	SZ-6ND-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 adaptive dimmer	RRD-6NA-	100% - 1%	1 – 8	1 – 4
Lutron	RadioRA® 2 1000 W dimmer	RRD-10ND-	100% - 1%	1 – 6	1 – 3
Lutron	myRoom DIN power module	MQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® QS wallbox power module	HQRJ-WPM-6D-120-	100% - 1%	1 – 26	1 – 13
Lutron	Homeworks® DIN power module	LQSE-4A1-D	100% - 1%	1 – 6	1 – 3
Lutron	HomeWorks® wallbox power module	HWI-WPM-6D-120	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® QS control unit	QSGR-, QSGRJ-	100% - 1%	1 – 26	1 – 13
Lutron	GRAFIK Eye® 3000 control unit	GRX-3100-, GRX-3500-	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4U module	HW-RPM-4U-120, LP-RPM-4U-120	100% - 1%	1 – 26	1 – 13
Lutron	RPM-4A module	HW-RPM-4A-120, LP-RPM-4A-120	100% - 1%	1 – 26	1 – 13
Lutron	GP dimming panels	Various	100% - 1%	1 – 26	1 – 13
Lutron	Ariadni CL 250W dimmer	AYCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Diva CL 250W dimmer	DVCL-253P-, DVSCCL-253P-	100%-1%	1 – 8	1 – 4
Lutron	Grafik T CL or RF CL dimmer	GT-250M-, GTJ-250M-	100%-1%	1 – 8	1 – 4
Lutron	Nova T CL 250W dimmer	NTCL-250-	100%-1%	1 – 10	1 – 5

* NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

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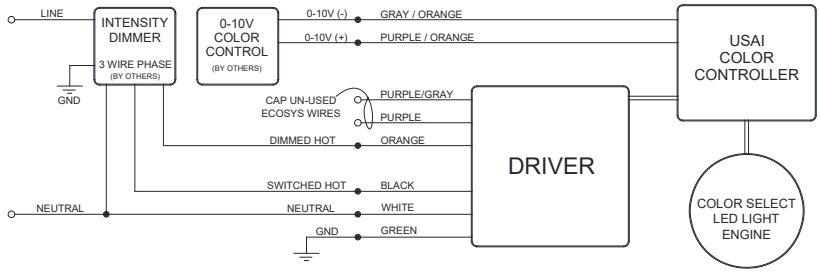
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML4

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML4 LED: Lutron Hi-Lume A-Series LED Driver with Eco System Control / LED Dimming Driver Wiring (Dims down to 1%)



D4 / DIML4 LED: Lutron Hi-Lume A-Series LED Driver with 3-Wire FL Control / LED Dimming Driver Wiring (Dims down to 1%)

D4 / DIML4 3-Wire Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V Only				39W and Less	40W - 80W
ETC	Sensor+ Cabinet	D20 Dimming module	100% - 1%	1–53	1–26
ETC	Unison DRd Cabinet	D20F Dimming module	100% - 1%	1–53	1–26
Lutron	Nova T	NTF-10-	100%–1%	1–41	1 – 20
Lutron	Nova T	NTF-103P-	100%–1%	1–20	1 – 10
Lutron	Nova	NF-10-	100%–1%	1–41	1 – 20
Lutron	Nova	NF-103P-	100%–1%	1–20	1 – 10
Lutron	Vareo	VF-10-	100%–1%	1–20	1 – 10
Lutron	Skylark	SF-10P-, SF-103P-	100%–1%	1–20	1 – 10
Lutron	Diva	DVF-103P-, DVSCF-103P-	100%–1%	1–20	1 – 10
Lutron	Ariadni	AYF-103P-	100%–1%	1–20	1 – 10
Lutron	Vierti	VTF-6A-	100%–1%	1–15	1 – 7
Lutron	Maestro	MAF-6AM-, MSCF-6AM-	100%–1%	1–15	1 – 7
Lutron	Maestro Wireless	MRF2-F6AN-DV-	100%–1%	1–15	1 – 7
Lutron	RadioRA 2	RRD-F6AN-DV-	100%–1%	1–15	1 – 7
Lutron	HomeWorks QS	HQRD-F6AN-DV	100%–1%	1–15	1 – 7
Lutron	Interfaces	PHPM-3F-120, PHPM-3F-DV	100%–1%	1–41	1 – 20
Lutron	GP Dimming Panels	Various	100%–1%	1–41	1 – 20
277V Only				40W and Less	41W - 80W
ETC	Sensor+ Cabinet	D20 Dimming module	100% - 1%	1–53	1–26
ETC	Unison DRd Cabinet	D20F Dimming module	100% - 1%	1–53	1–26
Lutron	Nova T	NTF-10-277-	100%–1%	1–44	1 – 22
Lutron	Nova T	NTF-103P-277-	100%–1%	1–33	1 – 16
Lutron	Nova	NF-10-277-	100%–1%	1–44	1 – 22
Lutron	Nova	NF-103P-277-	100%–1%	1–33	1 – 16
Lutron	Skylark	SF-12P-277-, SF-12P-277-3	100%–1%	1–33	1 – 16
Lutron	Diva	DVF-103P-277-, DVSCF-103P-277-	100%–1%	1–33	1 – 16
Lutron	Ariadni	AYF-103P-277-	100%–1%	1–44	1 – 22
Lutron	Vierti	VTF-6A-	100%–1%	1–33	1 – 16
Lutron	Maestro	MAF-6AM-277-, MSCF-6AM-277-	100%–1%	1–20	1 – 10
Lutron	Maestro Wireless	MRF2-F6AN-DV-	100%–1%	1–33	1 – 16
Lutron	RadioRA 2	RRD-F6AN-DV-	100%–1%	1–33	1 – 16
Lutron	HomeWorks QS	HQRD-F6AN-DV	100%–1%	1–33	1 – 16
Lutron	Interfaces	PHPM-3F-DV	100%–1%	1–88	1 – 44
Lutron	GP Dimming Panels	Various	100%–1%	1–88	1 – 44

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

USAI®

www.usailighting.com
info@usailighting.com

1126 River Road
New Windsor, NY 12553

T 845–565–8500
F 845–561–1130

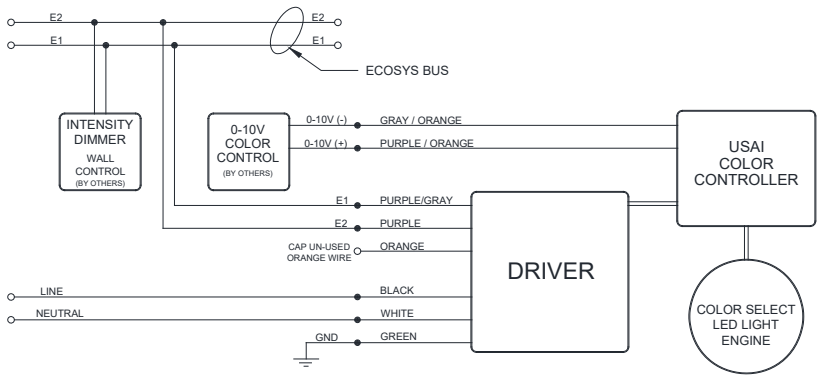
I2-228-4 Revised 09/26/2018

INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML4 Continued

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML4 LED: Lutron Hi-Lume A-Series LED Driver with Eco System Control / LED Dimming Driver Wiring (Dims down to 1%)



D4 / DIML4 LED: Lutron Hi-Lume A-Series LED Driver with EcoSystem Control / LED Dimming Driver Wiring (Dims down to

D4 / DIML4 EcoSystem Dimmer Compatibility Chart

Manufacturer	Product	Part Number	Dimmed Light Output Range	Qty Fixtures Per Control* Fixture Wattage	
120V / 277V				39W and Less	40W - 80W
Lutron	PowPak dimming module	RMJ-ECO32-DV-B	100%–1%	1–32	1–16
Lutron	Energi Savr Node	QSN-1ECO-S, QSN-2ECO-S	100%–1%	1–64	1–32
Lutron	GRAFIK Eye QS (120V ONLY)	QSGRJ- E, QSGR- E	100%–1%	1–64	1–32
Lutron	Quantum	Various	100%–1%	1–64	1–32

* NOTE: Number of fixtures may be higher if wattage is less than maximum values shown. Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

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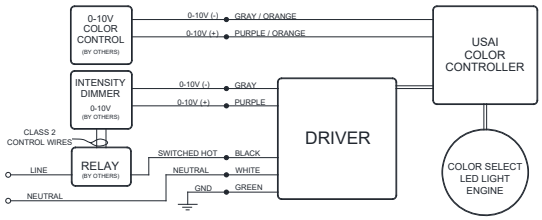
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML6A & 6B
DIML6E & DIML6F

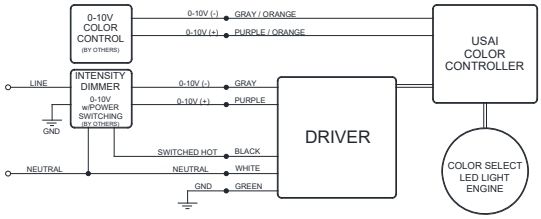
INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

0-10V Dimming w/ Relay Switch to Power



0-10V Dimming



D6A / DIML6A and D6E / DIML6E LED Dimming Compatibility Table

D6A / DIML6A and D6E / DIML6E are linearly programmed dimming drivers for use with the dimming controls listed in the table below
D6A / DIML6A = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1%
D6E / DIML6E = EldoLED ECOdrive 0-10V control dims from 100% to 1%

D6A / DIML6A and D6E / DIML6E Dimmer Compatibility Chart					
Manufacturer	Product	Part Number	Dimmed Light Output Range		Qty Fixtures Per Dimmer*
120V & 277V			DIML6A	6E	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Lutron	Diva	DVTV/NFTV with PP-20	99% -	0.1% 1%	
Lutron	Nova T	NTFTV with PP-20	99% -	0.1% 1%	
Lutron	Energi Savr Node	QSN-4T16-S	100% -	0.1% 1%	
Lutron	GP Dimming Panels	TVM2 Module	99% -	0.1% 1%	
Lutron	Interfaces	GRX-TVI w/ GRX3503	100% -	0.1% 1%	
Sensor Switch	nIO	nIO EZ	100% -	0.1% 1%	
enlighted	Control Unit	CU-3E-1R	100% -	0.1% 1%	

D6B / DIML6B and D6F / DIML6F LED Dimming Compatibility Table

D6B / DIML6B and D6F / DIML6F are logarithmic-programmed dimming drivers for use with the dimming controls listed in the table below
D6B / DIML6B = EldoLED SOLOdrive 0-10V control dims from 100% to 0.1% D6F / DIML6F = EldoLED ECOdrive 0-10V control dims from 100% to 1%

D6B / DIML6B and D6F / DIML6F Dimmer Compatibility Chart					
Manufacturer	Product	Part Number	Dimmed Light Output Range		Qty Fixtures Per Dimmer*
120V & 277V			DIML6B	6F	Refer to manufacturer's dimmer load rating for maximum and minimum fixture quantities per dimmer. Enlighted compatible.
Bush-Jaeger	Electronic potentiometer	2112U-101	100% -	0.1% 1%	
Jung	Electronic potentiometer	240-10	100% -	0.1% 1%	
Leviton	Illuma Tech dimmer	IP710-DLX	100% -	0.1% 1%	
Lightolier (Philips)	Momentum (120V ONLY)	ZP600FAM120	100% -	0.1% 1%	
Merten	Electronic potentiometer	5729	100% -	0.1% 1%	
Pass & Seymour	Titan	CD4FB-W	100% -	0.1% 1%	
Watt Stopper	Miro	DCLV1	100% -	0.1% 1%	
Synergy	Wallbox Dimmers	ISD BC	100% -	0.1% 1%	
ABB	i-bus	SD/S 2.16.1	100% -	0.1% 1%	
Crestron	Modules	GLX-DIMFLV8, GLXP-DIMFLV8	100% -	0.1% 1%	
Crestron	Green Light	GLPAC-DIMFLV4-, GLPAC-DIMFLV8-	100% -	0.1% 1%	
Crestron	Green Light Power Pack	GLPP-DIMFLVEX-PM, GLPP-1DIMFLV2EX-PM, GLPP-1DIMFLV3EX-PM	100% -	0.1% 1%	
Crestron	DIN Rail Analog Output Module	DIN-A08	100% -	0.1% 1%	
Crestron	DIN Rail 0-10V Fluorescent Dimmer	DIN-4DIMFLV4	100% -	0.1% 1%	
Crestron	iLux 0-10V Dimmer Expansion Module	CLS-EXP-DIMFLV	100% -	0.1% 1%	
enlighted	Control Unit	CU-3E-1R	100% -	0.1% 1%	

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CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.

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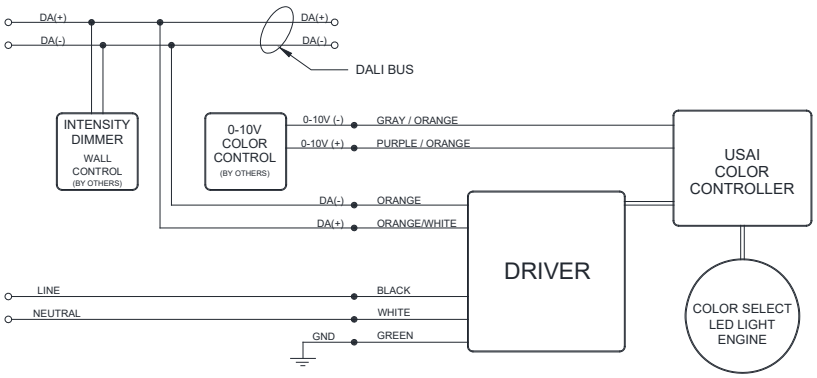
INTENSITY DIMMING DRIVER COMPATIBILITY SELECTION GUIDE
DIML7

INTENSITY DIMMING DRIVER WIRING SCHEMES:

Note: Wiring diagrams are examples of typical installations intended to illustrate the number of wires that must be run to fixture. These diagrams are not intended to specify all equipment necessary for a given dimming circuit. Refer to specific dimmer manufacturer's documentation for details.

DIML7 LED: eldoLED DALI dimming driver (dims down to 0.1%)



NOTE: Refer to dimmer manufacturer's documentation for installation instructions and circuit details.

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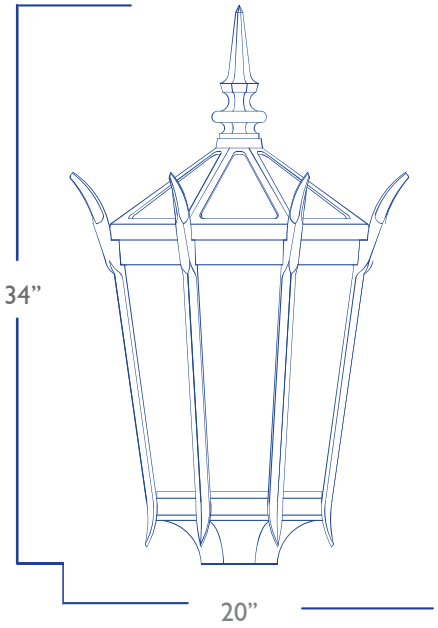
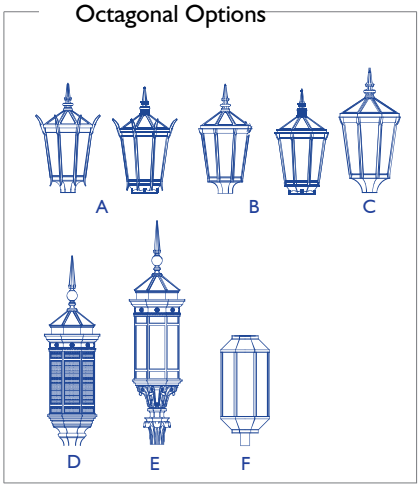
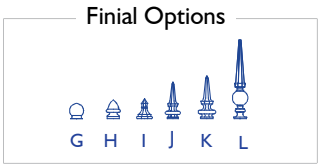
Spring City Octagonal LED





For additional size information
please visit www.springcity.com



ORDERING INFORMATION

BUILDING A PART NUMBER

Style	Lamping	Voltage	Number of Boards	Color Temperature	Optics	Panel Material	Panel Type	Finial	Finish
ALMEDM	LE100	EV1	X2	45	CR3	P	SDP	FED	CU

ALMEDM	=		
ALMEDL	=	A	Edgewater
ALMWMM	=		
ALMWML	=	B	William and Mary
ALMSVH	=	C	Savannah
ALMHRB	=	D	Harrisburg Baltimore
ALMHRR	=	E	Harrisburg
ALMDPM	=	F	Dana Pointe

LE020	=	20 W
LE030	=	30 W
LE040	=	40 W
LE060	=	60 W
LE065	=	65 W
LE080	=	80 W
LE095	=	95 W
LE100	=	100 W
LE120	=	120 W
LE125	=	125 W
*custom available		

EV1	=	120 V
EV8	=	208 V
EV2	=	240 V
EV7	=	277 V
EV4	=	480 V

X2	=	2 boards
X5	=	5 boards

22	=	2200 K
30	=	3000 K
40	=	4000 K
45	=	4500 K
60	=	6000 K

CR3	=	Type III
CR4	=	Type IV
CN5	=	Type V

P	=	Polycarbonate
Y	=	Acrylic

PLO	=	Clear
PLF	=	Fully Frosted
PBP	=	Pebbled
SDP	=	Seeded
STP	=	Stippled
WHP	=	White
XXX	=	Custom

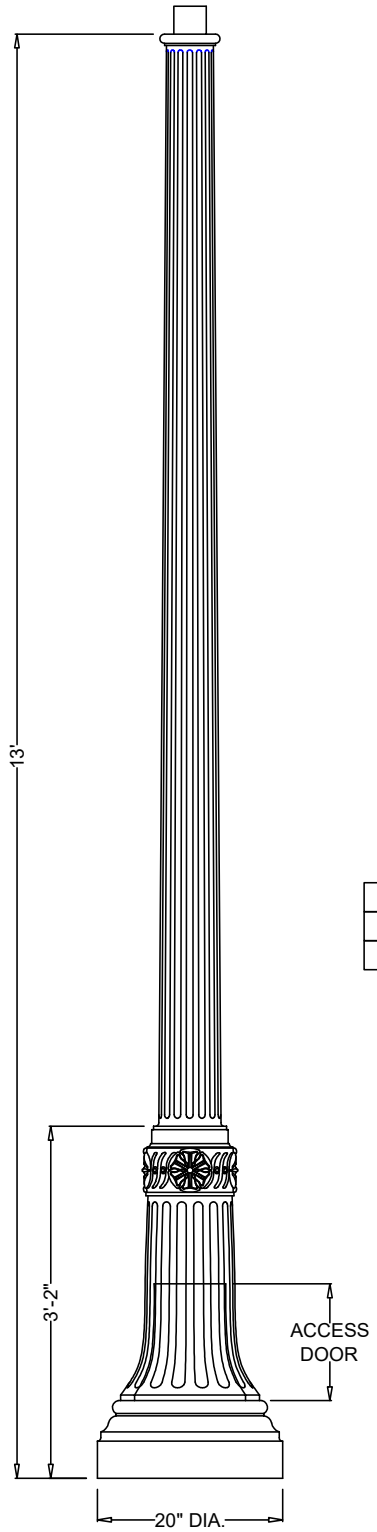
F03	=	G	Cast Ball
FGV	=	H	Grandview Finial
FNA	=	I	North Ave
FED	=	J	Standard Edgewater
FSA	=	K	Standard Savannah
FHB	=	L	Standard Harrisburg/Baltimore
XXX	=	N	Modifier

CU	=	Powder Coat
CW	=	Custom Wet Paint
BG	=	Bottle Green
CB	=	Classic Black
DB	=	Dark Bronze
GI	=	Gray Iron
LB	=	Long Beach Blue

I OCTAGONAL LED

Spring City™

One South Main St
Spring City, PA 19475
610-948-4000



LAMP POST SPECIFICATIONS

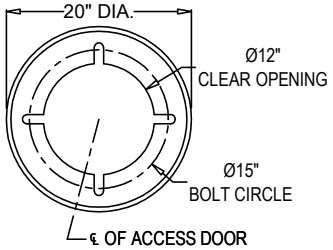
STYLE:	NORTHAMPTON
HEIGHT:	13'-0"
BASE:	20" DIAMETER
MATERIAL:	PLEASE ADVISE BELOW
FINISH:	PLEASE ADVISE BELOW
ACCESS DOOR:	LOCATED IN BASE SECURED WITH TAMPER PROOF HEX SOCKET SECURITY MACHINE SCREWS
GROUND PROVISIONS:	DRILL AND TAP INSIDE WALL OF BASE OPPOSITE ACCESS DOOR TO ACCOMMODATE A 1/4"-20 GROUND STUD (STUD SUPPLIED BY OTHERS)
ANCHOR BOLTS:	(4) 3/4" DIA. X 24" LONG + 3" HOOK (FULLY GALVANIZED WITH 1 GALVANIZED NUT AND 1 GALVANIZED WASHER PER BOLT)
BOLT PROJECTION:	3" REQUIRED
TENON:	PLEASE ADVISE BELOW

CATALOG NO.: _PSNRT-20-13.00-TN_.__/_.__-C_

MATERIAL	CAT. NO.
1 PIECE, CAST ALUMINUM ALLOY ANSI 356 PER A.S.T.M. B26-95	A
1 PIECE, CAST IRON PER A.S.T.M. A48-83 CLASS 30	I
1 PIECE, CAST DUCTILE IRON PER A536-84 GRADE 65-45-12	D

TENON	CAT. NO.
2 7/8" DIA. X 3" HIGH	TN2.88/3.00
3" DIA. X 3" HIGH	TN3.00/3.00
3 1/2" DIA. X 3" HIGH	TN3.50/3.00
4" DIA. X 3" HIGH	TN4.00/3.00
X.XX" DIA. X X.XX" HIGH	TNX.XX/X.XX

FINISH	CAT. NO.
POWDER COAT - PLEASE ADVISE RAL #	CU
PRIME PAINT THEN FINISH PAINT SHERWIN WILLIAMS - PLEASE ADVISE COLOR	CW

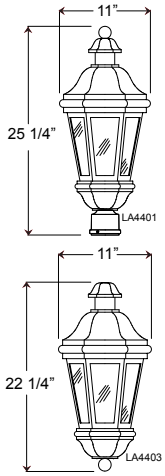


BASE PLATE DETAIL

Spring City Electrical Mfg. Co.
HALL AND MAIN STREETS - P.O. BOX 19 - SPRING CITY, PA. 19475
PHONE (610) 948-4000 - FAX (610) 948-5577 - WWW.SPRINGCITY.COM

DESCRIPTION	THE NORTHAMPTON 13'-0" LAMP POST

CUTSHEET NOTE: This document is for information only. Refer to specification for all model numbers, finishes, etc.



Project: _____

Fixture Type: _____ Quantity: _____

Customer: _____

Specifications

Material:
All parts are durable 356 cast aluminum. All hardware provided shall be stainless steel or zinc plated steel.

Lens:
Choice of acrylic lens or no lens

Fixture Mounting:
Post Mount: Post Cap with set screws.
Pendant Mount: Pin mount to tenon.
Fits 3" and 4" poles.

Drivers:
Universal voltage 120-277 is standard. 0-10V, TRIAC and ELV dimming to 1% protocols are standard for LED modules.

See page 2 table for LED module and driver specs, voltage and dimming protocols.

Electrical:
Approximately 12" of pull wire extends from luminaire. Additional pull wire provided for post mount arms and wall mounts.

Finish:
A polyester powder coat high quality finish is electro-statically applied and baked at 430° for exceptional durability and color retention. Products undergo an intensive five-step cleansing and pretreatment process for maximum paint adhesion.

Marine grade finish provides superior salt, humidity and UV protection. This coating withstands up to 3000 hours of continuous salt spray, comes with a 5-year warranty and is available in either a textured or gloss surface.

Modifications:
Consult factory for custom or modified designs.

LA440
LED

Weight: 7.7 lbs
EPA: 0.95

Catalog Logic

LA440	1	CL	M016LD	D	W	40K	-	PC	-	PA5651	-	72
Luminaire Series	Pendant or Post Mount	Lens	Light Source & Wattage	Dimming	Optics	CCT		Accessories		Mounting Source		Finish

Catalog Number	1	2	3	4	5	6	7	8	9
LA440				D			—	—	—

1 FIXTURE ORIENTATION

1 Post
3 Penda

2 LENS

NL (No Lens)
CL (Clear Acrylic)
PR (Prismatic Acrylic)
SE (Seeded Acrylic)
WH (White Opal Acrylic)

3 LIGHT SOURCE & WATTAGES

M012LD	(12w, 750 lumen, Cree module) Integral driver, 120V, TRIAC dimming & narrow (Type V) distribution only.
M009LD	(9w, 850 lumen, Cree module)
M010LD	(10w, 1250 lumen, Cree module)
M016LD	(16w, 2000 lumen, Cree module)

4 DIMMING

D (Dimming)

See page 2 table for LED engine and driver specs, voltage and dimming protocols.

5 OPTICS

W (T5 Wide Distribution with Dome LED Lens)

N* (T5 Narrow Distribution with Flat LED Lens)

***12w is narrow only, select "N".**

6 COLOR TEMPERATURE (CCT)

27K (2700K)
30K (3000
35K (3500
40K (4000K)

7 ACCESSORIES

CHC	(Clear Glass Chimney)
CHF	(Frosted Glass Chimney)
HSS90	(90° House Side Shield, polished)
HSS120	(120° House Side Shield, polished)
4ST36	(3 Ft, 1 1/4" Ridged Stem & Canopy)
PEND-CH3	(3 Ft Pendant Chain & Canopy)
***EMG-LED5**	(5w, LED Emergency Driver, remote placement, Cree module only)
***EMG-LED7**	(7w, LED Emergency Driver, remote placement, Cree module only)
***EMG-LED10**	(10w, LED Emergency Driver, remote placement, Cree module only)
HLMSPC-06	(High-Low Motion Sensor/Photocell; 15' - 30' Sensor Mounting Height)
HLMSPC-10	(High-Low Motion Sensor/Photocell; 8' - 15' Sensor Mounting Height)
PC	(Button Photo Cell)
SP	(Surge Protector, 10kA & 10kV)
TLPC	(Twist Lock photo cell & receptacle)
TL	(Twist Lock receptacle only)
TL5	(5-pin Twist Lock receptacle only)
TL7	(7-pin Twist Lock receptacle only)

***For Emergency lumen output data, see Resources section at www.ANPlighting.com.**

8 MOUNTING SOURCE

Post Mount Arms *See Page 3 for Style/Size		Wall Mount Arms *See Page 3 for Style/Size	
	A8521		
PA5153	**PA8523**	**WM3353**	**WM5603**
PA5411		**WM4511**	
PA5413		**WM4513**	
PA5611		**WM5131**	
PA5613		**WM5133**	
PA5651		**WM5161**	
PA5653		**WM5163**	
PA8031		**WM5311**	
PA8033		**WM5313**	
Column Mount *See Page 3 for Style/Size			
CM Column Mount			

9 FINISHES

Standard Grade	Marine Grade		Standard Grade	Marine Grade	
40	NA	Raw Unfinished	53	100	Copper Clay
41	101	Black	56	109	Silver
42	102	Forest Green	61	106	Black Verde
43	114	Bright Red	70	118	Painted Chrome
44	107	White	71	105	Painted Copper
45	112	Bright Blue	72	108	Textured Black
46	123	Sunny Yellow	73	125	Matte Black
47	120	Aqua Green	76	121	Textured Architectural Bronze
49	NA	Galvanized	77	127	Textured White
50	111	Navy	78	124	Textured Silver
51	103	Architectural Bronze	10	130	Aspen Green
52	104	Patina Verde	11	131	Cantaloupe
12	133	Lilac	13	132	Putty

Consult factory for additional paint charges and availability

11012018

1-800-548-3227
ANPlighting.com

Project: _____

Fixture Type: _____ Quantity: _____

Customer: _____

LED PERFORMANCE

MODULE

LED Wattage	CCT	Typical Luminous Flux	System Wattage	Typical Efficacy
9W	2700K	850	11W	97
	3000K	850	11W	97
	3500K	850	11W	97
	4000K	850	11W	97
10W	2700K	1250	12W	125
	3000K	1250	12W	125
	3500K	1250	12W	125
	4000K	1250	12W	125
12W	2700K	750	12W	65
	3000K	750	12W	65
	3500K	750	12W	65
	4000K	750	12W	65
16W	2700K	2000	19W	125
	3000K	2000	19W	125
	3500K	2000	19W	125
	4000K	2000	19W	125

MODULE SPECIFICATION

- Efficacy 65-125 lumens per watt
- Life: L70 50,000 hours
- Color temp: 2700K,3000K,3500K and 4000K
- CRI: >90

MODULE DRIVER SPECIFICATION

- Input Voltage: 120-277 Volts; 50/60Hz
- Dimmable down to 1%
- 0-10V, TRIAC and ELV dimming protocols are standard.
- Output Current: Constant Current: 440mA to 940mA (model dependent)
- Driver Efficiency > 80%; Power Factor > 0.9
- Integral Surge Protection in conformance to ANSI C62.41 Category A

MODULE LISTINGS

- Fully compliant with the RoHS Directive
- Certifications: CE/UL

WARRANTY

See www.ANPlighting.com for complete fixture warranty.

- 5 year limited warranty on Modules/Drivers

*Limited Warranty: A typical year is defined as 4380 hours of operation.

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1-800-548-3227
ANPlighting.com

Project: _____

Fixture Type: _____ Quantity: _____

Customer: _____

POST MOUNTS - See Post Arm Section on Website for Specification Sheets and additional post arms. Dimensions are Projection x Height

PA5151 / 14 1/4" x 19 3/4"

PA5153 / 14 1/4" x 19 3/4"

PA5411 / 17 7/8" x 25 1/8"

PA5413 / 17 7/8" x 25 1/8"

PA5611 / 18 5/8" x 26 1/2"

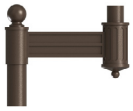
PA5613 / 18 5/8" x 26 1/2"

PA5651 / 20" x 26 1/4"

PA5653 / 20" x 26 1/4"

PA8031 / 20 1/2" x 20 1/4"

PA8033 / 20 1/2" x 20 1/4"



PA8521 / 18 1/4" x 14 1/2"

PA8523 / 18 1/4" x 14 1/2"

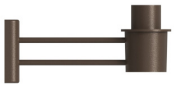
COLUMN MOUNT

CM / 5 3/4" SQ x 3 1/2" H

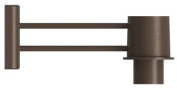
WALL MOUNTS - See Wall Mount Section on Website for Specification Sheets and additional wall mount arms. Dimensions are Projection x Height.

WM3351 / 14 1/2" x 17"

WM3353 / 14 1/2" x 17"



WM4511 / 17" x 8"



WM4513 / 17" x 8"

WM5131 /11" x 16 3/8"

WM5133 /11" x 16 3/8"

WM5161 / 15 3/4" x 17 3/4"

WM5163 / 15 3/4" x 13 3/4"

WM5311 /10 7/8" x 10"

WM5313 / 10 7/8" x 10"

WM5601 / 17 7/8" x 14"

WM5603 / 17 7/8" x 14"

ACCESSORIES

CHC & CHF

HSS90 & HSS120

4ST36

PEND-CH3

EMG-LED5, 7 & 10

HLMSPC-06 & HLMSPC-10

PC

TLPC

TL

TL5 & TL7

11012018

1-800-548-3227
ANPlighting.com

SECTION 270000
COMMUNICATIONS

PART 1 - GENERAL

1.2 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Carefully examine all of the Contract Documents for requirements, which affect the work of this section. The exact scope of work of this section cannot be determined without a thorough review of all specification sections and other Contract Documents.

1.3 BID REQUIREMENTS

A. Instructions to Bidders: To be considered, Bids must be made in accord with the Architect's Instructions to Bidders and this Article.

B. Examinations: Carefully examine the contract documents and the construction site to obtain first-hand knowledge of existing conditions. Contractors will not be given extra payments for conditions that can be determined by examining documents or site and will not be relieved of any obligations with respect to bid.

C. Questions: Submit all questions about the contract documents in writing. Replies requiring changes to the contract documents will be issued to all bidders as addenda and will become part of the Contract. The Architect and Owner may give but will not be responsible for oral clarifications. Questions received less than 10 days before bid date cannot be answered in writing.

D. Acceptable Products: Cornell University Information Technology (CIT) has standardized on products and has provided the design team with specific systems and manufacturers. Unless the specified product says or equal, the specified product is a CIT requirement. When it says, or equal, those model numbers and manufacturers identified herein indicate a standard of quality and performance. Other products will be considered subject to approval of complete technical data, samples and results of independent testing of proposed equipment submitted in accordance with Division 1 requirements and “Substitutions” section below.

E. Substitutions: Substitutions of products other than those of the acceptable manufacturers specified herein shall not be made. Only the specified items or the comparable product by one of the specified alternate products shall be submitted. Products by other manufacturers shall not be used on this project. Use of acceptable manufacturers shall meet or exceed this scheduled or designed product.

F. Performance Bond: The successful bidder will furnish a Performance Payment Bond and Labor and Material Bond, underwritten by a surety company approved by the Architect and Owner, for fulfillment of all provisions of the contract.

G. Basis of Bids:

1. Include a complete itemized list for each base-bid system indicating the manufacturer, model number, unit cost and total costs for all specified items.
2. Clearly indicate the total cost, including all expenses, for each individual system to allow the Owner to select any or all to be included in the contract.
3. Organize each list with the information presented, in the order that it appears in this specification, in 6 columns from left to right:
   a. Paragraph number as it appears in this specification.
   b. Paragraph title as it appears in this specification.
   c. Manufacturer and model number.
   d. Quantity.
   e. Unit Cost.
   f. Extension (unit cost times quantity).
4. At the end of each list indicate the cost of all other items such as for miscellaneous equipment, engineering, installation labor, overhead, taxes, etc.
5. On a separate list indicate costs of any specified add- or deduct-alternates with the information presented in the same manner as for the base-bid system.
6. Include any notes or comments if necessary to qualify the bid.
7. Identify any sub-contractors and indicate the work they are to do.
8. Provide documentation of ability in installing similar systems. Furnish the names, addresses and telephone numbers of the System Designer, Architect, General Contractor and Owner on three projects similar in scope, which the Contractor has installed within the last 5 years.
9. Include certification of ownership and full familiarity with the operation of the following minimum test equipment. Provide a list of the manufacturer, model, and serial number for each item of test equipment required.
   a. Handheld Test Set – “Butt Set”.
   b. Tone Generator & Amplifier Probe.
   c. Cablemeter and LAN Tester 5E/6/6A Compliant.
   d. Multi Mode Optical Loss Meter & Source Generator (850nm, 1300nm).
   e. Single Mode Optical Loss Meter & Source Generator (1500nm, 1300nm).
   f. Multi-mode – Single-mode Optical Time-Domain Reflectometer.
   g. Multi-mode – Single-mode fusion splicing systems.
   h. Fiber Optic Mechanical Splicing systems.
   i. Multimeter.

H. Furnish all material, labor, construction, tools, parts, supplies, etc., required for the installation. This includes all equipment, placement, restoration, raceways, cable, conduit, distribution components, connectors, and all associated equipment as applicable unless specified otherwise.

I. A pre-Installation meeting for coordination and scheduling between the general contractor, CIT and wiring contractor is required. The General Contractor will determine the work hours and site access.

J. All work pertaining to the installation of the cabling system shall be closely coordinated with CIT through the Client Representative.

K. Survey the facilities for all items necessary for designing and installing both the inside and outside plant routing, wiring, frames, protection, etc.

L. CIT reserves the right to appoint one (1) or more Project Inspectors to review the Bidder's work and ensure compliance with the contract and specifications. The Project Inspector shall at all times have access to the work.

M. Although Client's Representative is instructed to confer with the Bidder regarding interpretation and otherwise, such assistance shall not relieve the Bidder of any responsibility for the work. The fact that Client's Representative has failed to observe faulty work, or work done which is not in accordance with the drawings and specifications, shall not relieve the Bidder from responsibility for correcting such work without additional compensation.

N. If laws, ordinances, any public authority, any insurance rating bureau or these specifications require any work to be specifically tested or approved, the Bidder shall arrange for and give Client's Representative timely notice of the date fixed for such inspection.

O. Installers should exercise care in all operations around existing structures and equipment, and shall be responsible for and shall promptly repair all damage and defacement caused by their operations. All openings should be patched and fireproofed as required by code.

1.4 DESCRIPTION OF WORK

A. Perform work and provide material and equipment as shown on T series drawings or as specified and or indicated in this specification. Completely coordinate work of this section with work of other trades and provide a complete and fully functional installation.

B. Drawings and specifications are complimentary and must be used together. Contractor is responsible for using both documents together, T drawings and Division 27 specifications. Provide work specified and not shown, and work shown and not specified as though explicitly required by both. Although work is not specifically shown or specified, provide supplementary or miscellaneous items, appurtenances, devices and material obviously necessary for a sound, secure and complete installation.

C. All work shall comply with the requirements of the BICSI Telecommunications Distribution Methods Manual and with EIA/TIA 568, 569, 606, 607 and all applicable TSBs as well as to the New York Electric Code, OSHA, New York Building Codes, and all applicable federal, state, county, and city codes and local requirements.

D. The latest editions of these Codes and Standards shall be applicable unless otherwise designated. Where conflicts exist from one code to another, the more stringent requirement shall apply.

E. Give notices, file plans, obtain permits and licenses, pay fees and back charges, and obtain necessary approvals from authorities having jurisdiction as required to perform work in accordance with all legal requirements and with Specifications, Drawings, Addenda and Change Orders, all of which are part of Contract Documents.

F. At completion of construction, the contractor shall provide the following to CIT:
   1. Provide CIT cable schedule for service activation planning and horizontal cable records.
   2. As built drawings of each floor plan documenting the location and labeling of each telecommunication outlet and the approved Cornell labeling scheme. These drawings should be provided in AutoCAD.
   3. Electronic drawings documenting the rack and wall field elevations in the IDF.
   4. Test results of all the telecommunication systems called out in Part 3 Execution of this specification.

G. Prior to the start of the following tasks, work shall be reviewed and approved by designated representatives of CIT:
   1. Start of IDF layout.
   2. Start of station cable installation.
   3. Start of station cable termination.
   4. Start of outlet device termination/labeling.
   5. Start of final inspection process.

H. A combination of outlet boxes, conduit, ladder rack cable trays and J hooks will comprise the support system. Cable may not rest on ceilings, piping, ductwork, lighting, conduits, equipment or be attached to any structure above the ceiling other than the J-hooks and wall-penetrating sleeves. No cable(s) may droop over 8" in any length of run.

I. Cable may not touch any light fixture or other electrical device. Cable installation in the proximity of electrical motors, transformers, and other high EMI/RFI output devices shall be shielded in metal-grounded conduit. It is the Bidder's responsibility to identify these areas.

J. All openings for cables that penetrate wall partitions, exit corridors and stairways shall be sealed to maintain the integrity and ratings of the walls. Wall ratings are as indicated on the architectural drawings.

K. The successful Bidder(s) shall provide, lay out, install, test, and cut over all the necessary material, equipment, and miscellaneous hardware to serve the project. This includes the cable itself (all carrier conductors regardless of medium), placement of that cable, termination, protectors, grounding clamps, Velcro wraps, ladder rack cable trays, jacks, backboards, terminal blocks, jumpers, testing, boring, and all other labor, materials and supervision for a fully operational, turn-key inside plant system.

L. Cable shall be installed according to manufacturers' specifications and recommendations, including, but not limited to, minimum bend radius, pulling tension, sheath wrinkling, etc. and in accordance with prudent standards of practice.

M. Bidder's submissions must include all necessary patch and cross connect equipment panels, mounting hardware, equipment racks, etc.

N. Outlet Termination Requirements:
   1. All outlets to be installed in electrical boxes per installation details on T drawings unless otherwise noted. See T drawings for outlet configurations, locations and cable counts. All outlets will be terminated with the RJ-45 jack wired to EIA T568A standard. The number and placement of such outlets will vary based on the size and use of the space.
   2. Wire connections must be insulation displacement attached to a printed circuit board or approved alternative. IDC connectors must have color-coded labels with the corresponding PIN number printed in each colored band. Connector termination must require no tools other than manual hand pressure for press-on stuffer caps. All Category 6/6A connector modules must be clearly and permanently labeled.
   3. The Bidder shall supply faceplates of the same color, type, style, and manufacture for all locations.

4. All outlets will be marked with outlet ID according to a numbering plan developed by CIT. Label each location using machine printed labeling. Hand-written labeling is unacceptable and shall not be used.
5. Use industry standard EIA/TIA color code and maintain consistent coding throughout the system installation.
6. Unattached wire drops from ceiling are not acceptable.

O. Related Work Specified Elsewhere:
1. See Sustainability 01 81 13.
2. Metals 05 00 00.
3. Rough Carpentry 06 10 00.
4. Finish Carpentry 06 20 10.
5. Acoustical Ceilings 09 20 00.
6. Heating Ventilation and Air Conditioning 23 00 00.
7. Communications 27 00 00.

1.5 QUALITY ASSURANCE

A. Successful bidder shall be thoroughly familiar with the cabling methods set forth in the latest release of the BICSI TDMM and unless otherwise specified, shall bidder win project, bidder shall supervise the installation in accordance with the recommendations and practices outlined in the latest release of the BICSI Telecommunications Installation Manual.

B. Installer shall be a Panduit trained and certified installer and provide a twenty (20) year extended product warranty and application assurance warranty for the Category 6 and 6A copper system.

C. Installer shall be a Corning trained and certified installer and provide a twenty (20) year extended product warranty and application assurance warranty for the fiber optic cable distribution system.

D. Contract Documents: Maintain a full size, complete set of as-built Technology drawings and specifications at the site at all times during installation. Mark on these drawings, with red ink, changes to the contract documents as warranted by field conditions or owner requested changes.

E. The successful bidder shall have at least five (5) years experience installing and servicing Telecommunications Systems, and shall provide a list of completed projects equivalent in size and complexity to this project, with contact names and telephone numbers.

F. The successful bidder shall submit in writing a list of qualified technicians assigned to this project, including relevant manufacturers training programs completed by each, and years of related experience of each.

G. The successful bidder shall maintain an office or competent technical presence with appropriate testing equipment and replacement parts within 2 hour drive time from this project location.

H. Project Management: The successful bidder must identify and provide an on-site project manager who will supervise the daily activities of the project and who will be the conduit of communications with the other contractors, the general contractor, the University and other vendors. The project manager may be required to attend periodic project meetings called by the Cornell Project Manager and or the general contractor.

I. Fabrication and Installation: Fabricate all equipment racks and subassemblies. Continuously supervise the installation and connections of cable and equipment.

1.6 SUBMITTALS

A. Conform to the requirements of Division 1, General Conditions, for schedule and form of all submittals unless specifically noted otherwise in this section. Coordinate this submittal with submittals for all other finishes. Shop drawings and design layouts shall be prepared by installing Contractor.

B. Definitions:
1. Shop Drawings are information prepared by the contractor to illustrate portions of the work in more detail than indicated on the contract documents.
2. Data Sheets are product catalog cut sheets.
3. Coordination drawings are 3/8" plans coordinating the layout of telecommunication equipment with the equipment of other trades.

C. Submittal Procedures, Format and Requirements.
1. Provide (1) complete submittal package for compliance with Contract Documents to General Contractor for review.
2. Provide submittal package in electronic pdf sheets as specified by GC or architect.
3. Submit a numbered table of contents. Numbers shall correspond to the page numbers of the product data sheets.
4. Submit only complete submittal packages. Incomplete submittal packages will be rejected in its entirety.
5. Each Shop Drawing shall indicate a title block. Each Product Data package shall indicate on cover sheet, the following information:
   a. Title
   b. Equipment number
   c. Name and location of project
   d. Names of Owner, Engineer and Seller
   e. Names of manufacturers, suppliers, vendors, etc.
   f. Date of submittal
   g. Whether original submittal or resubmitted
6. Shop Drawings showing manufacturer‘s product data shall contain detailed dimensional drawings (minimum ¼" – 1‘ scale) including plans and sections (where physical clearance could be an issue). Provide larger scale details as necessary.
7. The product data sheets shall be marked by the contractor with an indicating arrow identifying what product and model number and option is being submitted.
8. Product data sheets that are not marked with indicating arrow will be rejected.
9. Acceptable Manufacturers: Provide products as specified in this section. The mechanical design for each product is based on the manufacturers shown on the drawings and in the specifications.

10. Submit accurate and complete description of materials of construction, manufacturer‘s published performance characteristics, sizes, weights, capacity ratings (performance data, alone, is not acceptable), electrical requirements, Btu's, wiring diagrams, and acoustical performance for complete assemblies.
11. The Owner‘s Representative shall approve all materials before commitment for materials is made.

D. Product Data: Material and equipment requiring shop drawings submittals shall include but not limited to:
1. Faceplates
2. Data Module Inserts (Category 6/6A)
3. Data Horizontal cable (Category 6/6A)
4. Data Patch Panels (Category 6/6A)
5. Fiber Optic Backbone Cable
6. Fiber Optic Termination Hardware
7. Wall Telephone Faceplate
8. Category 3 Copper Backbone Cable
9. Telecommunications Racks
10. Cable Supports and Management
11. Cable Runway/Ladder Rack
12. Fire stopping Material
13. Outlet, cable, 110 terminal block and patch panel ID labels.
14. Proof the installation contractor can provide 20 year Panduit warranty.
15. Operations and Maintenance Manuals - See part III
16. Warranties, parts list, etc. See Operations and Maintenance Manuals - See part III

E. Deviations:
1. Concerning deviations other than substitutions, proposed deviations from Contract Documents shall be requested individually in writing whether deviations result from field conditions, standard shop practice, or other cause. Submit letter with transmittal of Shop Drawings which flags the deviation to the attention of the Owner‘s Representative.
2. Without letters flagging the deviation to the Owner‘s Representative, it is possible that the Engineer may not notice such deviation or may not realize its ramifications. Therefore, if such letters are not submitted to the Owner‘s Representative, the Seller shall hold the Engineers, his consultants and the Owner harmless for any and all adverse consequences resulting from the deviations being implemented. This shall apply regardless of whether the Engineer has reviewed or approved shop drawings containing the deviation, and will be strictly enforced.
3. Approval of proposed deviations, if any, will be made at discretion of Engineer.

F. Schedule: Incorporate shop drawing review period into construction schedule so that Work is not delayed. This Contractor shall assume full responsibility for delays caused by not incorporating the following shop drawing review time requirements into his project schedule. Allow at least 10 working days, exclusive of transmittal time, for review each time shop drawing is submitted or resubmitted with the exception that 20 working days, exclusive of transmittal time are required for the following:
1. Coordination drawings.
2. If more than five shop drawings of a single trade are received in one calendar week.

G. Responsibility
1. Intent of Submittal review is to check for capacity, rating, and certain construction features. The Contractor shall ensure that work meets requirements of Contract Documents regarding information that pertains to fabrication processes or means, methods, techniques, sequences and procedures of construction; and for coordination of work of this and other Sections. Work shall comply with approved submittals to extent that they agree with Contract Documents. Submittal review shall not diminish responsibility under this Contract for dimensional coordination, quantities, installation, wiring, supports and access for service, nor the shop drawing errors or deviations from requirements of Contract Documents. The Engineer's noting of some errors while overlooking others will not excuse the Contractor from proceeding in error. Contract Documents requirements are not limited, waived nor superseded in any way by review.
2. Inform Contractor, manufacturers, suppliers, etc. of scope and limited nature of review process and enforce compliance with contract documents.

H. In the event that the Contractor fails to provide Shop Drawings for any of the products specified herein:
1. The Contractor shall furnish and install all materials and equipment herein specified in complete accordance with these Specifications.
2. If the Contractor furnishes and installs material and/or equipment that is not in complete accordance with these Specifications, he shall be responsible for the removal of this material and/or equipment. He shall also be responsible for the replacement of this material and/or equipment with material and/or equipment that is in complete accordance with these Specifications, at the direction of the Owner‘s Representative.
3. Removal and replacement of materials and/or equipment that is not in complete compliance with these Specifications shall be done at no extra cost to the Owner.
4. Removal and replacement of materials and/or equipment that is not in complete compliance with these Specifications shall not be allowed as a basis for a claim of delay of completion of the Work.

1.7 REFERENCE STANDARDS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only. All publications are intended to be the most current editions.

B. Except where otherwise noted all material and workmanship shall conform to the following standards:
1. TIA-526-7-A Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
2. TIA-526-14-C Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant
3. TIA-568.0-E Generic Telecommunications Cabling for Customer Premises
4. TIA-568.1-D Commercial Building Telecommunications Cabling Standard
5. TIA-568.2-D Balanced Twisted Pair Telecommunications and Component Standards
6. TIA-568.3-D Optical Fiber Cabling Components Standard
7. TIA-568-C.4-D Broadband Coaxial Cabling and Component Standard
8. TIA 569-E Telecommunications Pathways and Spaces

9. TIA 606-C Administration Standard for Telecommunications Infrastructure
10. TIA 607-D Generic Telecommunications Grounding (Earthing) and Bonding for Customer Premises
11. TIA 758-B Customer Owned Outside Plant Telecommunications Infrastructure
12. ASTM E 814-13a Standard Test Method for Fire Tests of Through-Penetrations Fire Stop Systems.
13. NFPA 70 National Electrical Code
14. ANSI/IEEE Std. 1100-2005 Recommended. Practice for Powering and Grounding Electronic Equipment (IEEE Emerald Book).
15. New York State Building Code
16. New York State Electrical Code
17. National Fire Protection Association (NFPA) 101 Life Safety Code
18. National Electric Code (NEC)
19. Williams-Steiger Occupational Safety and Health Act of 1970 (OSHA) - Public Law 91-596
20. Institute of Electrical and Electronics Engineers (IEEE)
21. Underwriter's Laboratories, Inc. (UL), Federal Specifications
22. Rural Electric Association - Telephone Division Standards
23. FCC Codes and Regulations

1.8 PERFORMANCE CRITERIA

A. All telecommunications cable shall operate in conformance to ANSI/TIA 568.1-D Commercial Cabling standards as designated for premise cable systems.

1.9 REQUIREMENTS OF REGULATORY AGENCIES

A. Conform to National Electric Code (NEC) Article 770 and New York fire codes.

1.10 JOB CONDITIONS

A. Sequencing and Scheduling:
   1. Coordinate work with adjacent work of other trades to facilitate construction and prevent conflicts with the general contractor.
   2. Afford other trades reasonable opportunity for installation of work and for the storage of materials.
   3. Staff the job to keep pace with the other Trades; otherwise, the Architect will require an increase in force or overtime work without additional expenses to the Owner.
   4. Abide by the decision of the Architect in case of conflict or interference by other trades.
   5. Refuse: Remove all refuse from the job site to the satisfaction of the Architect and Owner.

B. Insurances on the work of this specialty trade shall be provided as specified in Section Division 01.

C. The Contractor shall maintain telecommunications services within the project scope during all phases of work except where directed otherwise by the General Contractor.

D. The contractor shall provide temporary telecommunications service to the site construction trailers. Coordinate number of trailers and service with owner and general contractor.

E. The Contractor shall perform all work in accordance with the project phasing plans.

F. The routing of station cables from the serving telecommunications room to outlet locations shown on the Drawings is approximate. The Contractor shall determine the exact routing of horizontal station cables in the field and as approved by the General Contractor and/or Architect.

G. Where wire and cable routing is not shown, and destination only is indicated, the Contractor shall determine exact routing and lengths required. The Contractor shall document all actual cable routing.

H. The Contractor shall be responsible for any loss of telecommunications service resulting from inaccurate or omitted information regarding existing telecommunications cable systems.

1.11 WARRANTY:

A. Warranty the Panduit structured cabling system, end-to-end for a period of twenty (20) years. This will include all Contractor supplied components, including but not limited to wire, termination connections and panels. And the fitness of the system to carry Ethernet traffic through Gigabit/sec speeds as specified above.

B. Warranty the fiber optic distribution system. The contractor shall carry the Corning Cable Systems (CCS) Network Preferred Installer Warranty.

1.12 TRAINING

A. The Owner may assign personnel to participate with the contractor during installation. Without delaying the work, familiarize the Owner's personnel with the installation, equipment, and maintenance.

B. During tests and adjustments, permit the Owner's personnel to observe. When feasible explain the significance of each test.

C. Provide sufficient training to personnel selected by the Owner on operation and basic maintenance of all systems and equipment. Explain operation of control systems, set-up and operation of individual pieces of equipment and functions of overall systems.

D. Separate from the bid response quotation, provide an hourly cost for additional training.

1.13 INSPECTION

A. Notify the Architect of any defects in work by other trades affecting installation.

PART 2 - PRODUCTS

2.1 COMMUNICATIONS INFRASTRUCTURE

B. Telecommunications Enclosures - Rack
1. Provide 45 RU two post extruded aluminum rack.
2. Rack shall meet EIA-310D standards and be capable of accepting equipment that is 19" wide.
3. Rack shall be UL listed for 1500 lbs. load rating.

a. Panduit R2P6S

C. Vertical Cable Manager
1. Provide high capacity vertical cable mangers capable of mounting to EIA racks to manage cables on the front and rear of rack.
2. The manager shall be molded out of plastic and possess cable management fingers and pass through holes.
3. The vertical manager shall have a dual hinged metal door that can be opened to the left or the right.
   a. Panduit NRV10

D. Horizontal Cable Manager
1. Provide high capacity horizontal cable mangers capable of mounting to EIA racks to manage cables on the front of rack.
2. The manager shall be molded out of plastic and possess cable management D rings.
3. The managers shall be closed cable managers, 2 rack units high and black.
   a. Panduit WMPF1E

E. Ladder Rack
1. Provide Chatsworth Universal cable runway, black, 24" wide, part number 10250-724
2. Provide Chatsworth 11302-X01 junction-splice kit to create 90 junction splices.
3. Provide Chatsworth 11959-X24 cable runway corner bracket, 24" wide for corner radii.
4. Provide Chatsworth 11301-X01 Butt-splice kit to connect two section of cable runway.
5. Provide Chatsworth 12100-X12 cable runway radius drops. These 12" wide drops shall be installed in pairs as the runway is 24" wide.
6. Provide Chatsworth Cable to runway wall to rack kit with J bolts, mounting plate, end caps and wall angle support bracket.

F. J-Hook Cable Supports
1. Provide open top cable supports, J-Hooks, 2" diameter loop with Velcro closer on top.

G. Communication Copper Backbone Cabling - 50 Pair
1. Cable shall be Category 3, ARMM series and riser rated.
2. ARMM cable shall be grounded and bonded.
3. ARMM cable shall be Superior Essex 50 pair CMR 02-100-03

H. Armored Fiber Optic Building Backbone
1. Primary fiber optic building backbone system infrastructure shall consist of (1) 12 strand, singlemode 8.3/125 micron OFNP with interlocking armor OFNP Plenum rated, nonconductive DS series, Corning fiber optic cable.
2. Terminate all fiber strands with duplex SC Corning UniCam connectors.

I. Communication Copper Horizontal Cabling - WiFi
1. Category 6A horizontal cable for WiFi communications shall be 4 pair, 24 AWG, plenum, category 6A, green jacket.
   a. Commscope Sytimax 1091B.
   b. Berk Tek LANmark-XTP Plenum Category 6A

J. Communication Copper Horizontal Cabling - Data / Voice
   1. Category 6 horizontal cable for data and voice communications shall be 4 pair, 24 AWG, plenum, Category 6.
      a. Panduit GenSPEED 6000.
      b. Commscope-Systimax 1071E
      c. Berk-Tek Lanmark 1000
      d. Superior Essex DataGain
      e. Color to be blue.

K. Modular Inserts - WiFi
   1. Single modular inserts for WiFi communications shall be Cat6A Panduit CJ6X88TG jack modules.
   2. Color to be electric ivory.

L. Modular Inserts - Data/Voice
   1. Single modular inserts for data and voice communications shall be Cat6 Panduit CJ6X88TG jack modules.
   2. Color to be Electric Ivory.

M. Patch Panels - WiFi
   1. 48 port, Cat 6A, 10Gb/s patch panel with 48 RJ45 8-position, 8 wire ports.
   2. Panduit DP486X88TGY

N. Patch Panels - Data/Voice
   1. 48 port, Cat 6, 10Gb/s patch panel with 48 RJ45 8-position, 8 wire ports.
   2. Panduit DP48688TGY

O. Fiber Optic Closet Connector Housing
   1. Black, 2RU, indoor, front and rear access, lockable, fiber optic housing to hold four CCH connector panels.
   2. CCH-02U.

P. Fiber Optic Closet Connector Housing Panels (CCH-CP)
   1. CCH-CP12-59 12 strand fiber single-mode (OS-2) SC Duplex panels.

Q. Fiber Optic for Audio Visual
   1. 6 fiber Clearcurve, tight-buffered, singlemode riser cable.
   2. Corning 006u81-31131-24

R. Faceplates
1. Single gang 1 port faceplate shall be Panduit Executive Series, CFPE1E1Y. Color shall be electric ivory.
2. Single gang 2 port faceplate shall be Panduit Executive Series CFPE2E1Y. Color shall be electric ivory.

S. Wall telephone Faceplate
1. Single gang faceplates shall be Panduit.

T. Telecommunications Ground Busbar (TGB):
1. Provide TGB to be connected telecommunications grounding system.
2. Provide stainless steel brackets and fasteners.
3. Provide insulated standoffs
4. Busbar shall be 2" x 10" x 1/4" and UL listed
5. Acceptable Manufacturer:
    a. Chatsworth 13622-010

U. Stand-Off Insulator Specifications
1. Dielectric strength: 19,000 - 21,000 volts S.T.
2. UL 94v-0 Flame Resistant
3. Finish Color: Red
4. Insert Size and Material:3/8-16 x 5/8"D UNC-2B Aluminum
5. Dimensions: 2.5"W x 2.5" D

V. Plywood Backboards:
1. Backboards: Plywood, fire-retardant treated ¾” thick by 48” by 96”. Paint with fire retardant light colored paint. Do not paint over factory stamp that indicates fire rating of the plywood.
2. Comply with requirements in Division 06 Section "Rough Carpentry" for plywood backing panels.
3. Refer to Plans and Details for additional information.
4. Backboards shall be AC grade with the ‘A’ side (smooth) facing out.

PART 3 - EXECUTION

2.1 GENERAL

A. Work shall be executed in a workmanlike manner and shall present neat, plumb, and perpendicular to the building structure and parallel to electronic devices and cabling. Mechanical appearance when completed must adhere to the standards as set forth in BICSI Installation Standards. Maintain maximum headroom at all times. Do not run work exposed unless shown exposed on drawings. Material and equipment shall be new and installed in according to manufacturers recommended best practices to that the complete installation shall operate neatly, safely and efficiently.

B. Completely remove all temporary materials, facilities and equipment their use is no longer required. Clean and repair damage caused by temporary installations.

C. Contractor shall ensure that excess materials are removed from the job site upon completion and acceptance of project work. Excess materials removed from the job site shall be credited to the owner. Additionally, upon completion of the project, all contractor equipment will be removed.

D. All equipment except portable equipment shall be firmly held in place. Fastenings and supports adequate to support their loads with a safety factor of at least three unless otherwise stated.

E. Take such precautions as necessary to prevent and guard against electro-magnetic and electro-static hum and to install the equipment so as to provide safety for the operator.

F. Protect all equipment, including patch panels, connectors, receptacles, racks, consoles from construction dust and debris until final acceptance of the system.

2.2 INSTALLATION

A. General Instructions:
1. Coordinate all on-site installation mounting and routing with architect, consultant, and Owner.
2. All work shall be done at such times as the General Contractor shall deem appropriate. Work shall not begin in any area without specific notification of, and approval by General Contractor and/or Architect.
3. Cables shall be run along all routes as shown on the Drawings.
4. No splicing of any cables is allowed.
5. All cables shall be terminated at each end as show on the Drawings.
6. Protect all equipment, including patch panels, connectors, receptacles, and racks from construction dust and debris until final acceptance of the system.
7. The Contractor shall install all provided and furnished material in accordance with manufacturer's specifications, recommendations and guidelines. Copies of the manufacturer's guidelines, specifications and recommendations shall be provided by the Contractor to the General Contractor and Architect and shall be made available on site to the Contractor's personnel.
8. Install all wiring and cabling in accordance with the National Electric Code (NEC) where the provisions of the NEC are applicable.
9. Installation, including termination and connectorization, shall be in conformance with generally acceptable telecommunications means and methods and the manufacturer's specifications. Stress on any cable during installation shall not exceed manufacturer's specifications.
10. Install all cable, connectors, and terminations using installation locations as shown on Contract Drawings. Cable routes should be approved by the Architect in advance of installation.
11. The Contractor shall coordinate installation of all communication/data wiring to promote ease of installation and higher cable counts in conduits.
12. General Application Installations Instructions: The Contractor shall coordinate the temporary and permanent relocation of existing telecommunication cable and equipment with the General Contractor and Architect.

B. Site Survey and Inspection:
1. Prior to placing any horizontal, riser or outside plant cable, penetration, etc. the Contractor shall survey this site to see that job conditions do no impose any obstructions that would interfere with safe and satisfactory placement of the cables, and arrange with the General Contractor and Architect for the removal of any obstructions. The Contractor shall provide shop drawings for approval by the Architect prior to starting work.

2. The Contractor is responsible for notifying the General Contractor and Architect as soon as field conditions prevent proper installation. Claims will not be entertained after cable pulling has started.
3. The Contractor shall verify site conditions and dimensions of equipment to ensure access for proper installation of equipment without disassembly which will void warranty, and shall report in writing to the General Contractor and Architect prior to purchase or shipment of equipment involved, on conditions which may prevent proper installation
4. The Contractor shall survey existing conditions to determine the quantity and locations of existing telecommunications cable that is to remain active during construction. The Contractor shall take the required measures to protect this cable during all phases of the construction.
5. The Contractor shall inspect all cable as it is pulled off the reel for any obvious defects. If defects are observed, further use of the cable from this reel will be halted.

C. Cabling, Routing & Placement:
1. Routing:
   a. Horizontal cable distribution shall in general be installed in conduit from outlet box to MDF/IDF. Conduit from outlet box shall extend to an accessible ceiling. The cable will then be supported by an approved method as defined on the T drawings and in these specifications. In no instance shall the Contractor attach cables to any members, other cable, or support not specifically for that purpose. When any cable is pulled through a conduit or poke-through, a pull line is to be left in place in the conduit or poke-through to facilitate the installation of future cables. Two feet of slack shall be left at the top of the stub-up or bottom of the poke-through for services.
   b. Cables shall enter the MDF/IDF only through bushed sleeves or other properly installed structural penetrations. Punching and patching holes directly in sheet rock and cinder block is not permitted. Route all cables in such a manner as to protect them from present and future damage.
2. Route Preparation:
   a. Coordinate the drilling of holes in the concrete slab, sheet rock walls and any other required building penetrations with the General Contractor and Architect. Field coordination with the General Contractor and Architect is required prior to installing cables trays (where specified), sleeves, wall or floor penetrations and/or cables.
   b. Coordinate any ladder rack cable tray work with the General Contractor and Architect.
   c. Install raceway/tray as required in order to distribute the data lateral cables within telecommunications rooms.
3. Cable Placement:
   a. The proper installation of cable supports requires that each support carry only the weight of the cable from the next lower support or termination.
4. Pulling Tension:
   a. Maximum pulling tensions for 4 pair horizontal UTP cable shall not exceed 110N (25 lbf). Pulling tension should be monitored with a tension gauge.
   b. If multiple cables are to be pulled at one time, make the necessary allowances to back-off the pulling tension of the bundle.
   c. Cable pulls shall be protected by means of an overload cutoff or breakaway clutch set at somewhat less than the cable manufacturer maximum recommended pulling tension.

5. Bend Radii:
   a. All cables shall be installed with a bend radius greater than that recommended by the manufacturer.
6. Slack:
   a. Install 12" slack prior to termination at the outlet end.
7. Securing Methods:
   a. Provide vertical and horizontal cable ladders, D-rings and strain relief based upon field conditions to maintain orderly organization.
   b. Secure all cabling in a way to satisfy any structural engineering requirements.
   c. Obtain required structural engineering related information for any item which may affect the infrastructure of the building, and submit the information to the Architect for prior review and approval.
   d. Provide suspended platforms, threaded rods, strap hangers, bracket, shelves, stands or legs a necessary for floor, wall or ceiling mounting of equipment provided under this Section. Provide steel supports and hardware for proper installation of hangers, anchors, guides, etc., and shall provide cuts, weights, and other pertinent data required for proper coordination of equipment support.
   e. Do not use velcro wraps in ladder rack cable trays. Cables shall be splayed to avoid crosstalk.
   f. Provide strain relief at ladder rack cable tray exit points.
8. Placing Cable in Conduit:
   a. Verify that any conduits to be employed are clear of obstructions unless an exception has been approved in writing by the Architect.
   b. A fish line and mandrel shall be used to clear the conduit of obstructions and as a guide for pulling the cable through. A nylon drag line shall be pulled along with each conduit run installed so that future cables may be pulled in that conduit. Conduit bushings shall be used to protect the cable jacket from abrasion as it is pulled through conduit and at each exposed end.
   c. Cable pathways are typically provided and or installed by the EC. The pathways shall be parallel to building lines and shall sweep/turn 90 degree angles maintaining minimum bend radius for cable and will comply with TIA-569-C.
9. Lubrication:
   a. As necessary, for cable pulls in conduit, use a cable-manufacturer approved lubricant compatible with the cable’s outer jacket.
10. Protection:
    a. During installation, and prior to final acceptance, protect finished and unfinished work against damage and loss. In the event of such damage or loss, replace or repair such work at no additional cost. As cable is installed, care must be take to avoid knick, kinks or other damage to the cable. Cable is to be labeled at each end as specified in EIA/TIA standards. Provide strain relief at each termination point and enough slack to easily re-terminate the cable, if required later.
11. Cable Routes And Clearance:
    a. Home-run all riser cables between the identified termination blocks, panels and connectors in accordance with the route specified on the contract drawings.
    b. Home run all lateral/local distribution cables to the assigned telecommunications room.

c. To avoid EMI interference, all distribution should provide clearance of at least:
   1) 4 feet from large motors and or transformers
   2) one foot from conduit and cables used for electrical distribution
   3) five inches from fluorescent lighting.

d. Horizontal distribution pathways should cross perpendicular to fluorescent lighting and electrical power cables and conduits.

e. Cable runs above suspended ceiling shall be supported in the ceiling either by:
   1) J-hook supports shall be installed in accordance with the manufacturers recommendations and located at intervals such that the cables do not rest on ceiling tiles or grid at any point along the pathway.
   2) Where ladder rack cable tray and conduit are not provided for support of the telecommunication cables, cables shall be supported at a spacing of 4' - 5' intervals. Under no circumstances shall cable be laid on suspended ceiling.
   3) Cable runs shall be free of tension at both ends as well as over the length of the run. The cable shall be wired in a single plane above the suspended ceiling and not draped over ducts, beams or pipes.

D. Termination:
1. Terminate and test horizontal data cables from each data module insert to its corresponding patch panel.
2. All four pairs of each data horizontal cable shall be terminated on both ends to the T568-A wiring pin assignment standard.
3. Terminate 24 of each cable in all cables contiguously in color coded sequence. Terminate all pairs contiguously on one row of the patch panel. Place labels so as to remain legible upon completion of termination.
4. Apply data labels, and blank inserts to the faceplate and snap in place. Apply numbered outlet labels prior to completion of testing. Testing is not considered complete in the absence of labeling.
5. Terminate cable at outlet jacks in accordance EIA/TIA 568A standards as per school. Protect bare cable ends until connectors are installed.
6. Maintain cable twist to within 1/2" of the main point of insulation displacement contact.
7. For all standard and convenience wall mounted outlets, pull the cable through the stub down conduit to the outlet box, cut down and terminate the cable on jacks and mount the outlet in the gang boxes or dog houses for poke-throughs.

E. Grounding:
1. Generally, the grounding system is existing. Provide a suitable telecommunications ground for new sleeves as required per ANSI/TIA/EIA-607B Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications (August 2011).
2. All metallic sheathed and armor clad cables shall be bonded and grounded to TGB with approved bonding assemblies. Riser cables shall be bonded to the DF frame and to the cable sheaths of the associated distribution riser cable at splice locations. Distribution riser cables shall be bonded to the metal frames of the mounting hardware in the TR using bonding clamps appropriate to the size of the cable. The DFs shall be grounded to building ground in accordance with TIA-607-B. Ladder rack cable trays are to grounded and bonded for safety per NEC standards.

F. Splicing:
1. No splicing of any cables will be performed unless otherwise explicitly noted in contract drawings or pre-approved in writing by the Architect.

G. Materials Management:
1. Equipment materials shall be properly stored, adequately protected and carefully handled to prevent damage until acceptance.
2. Ensure delivery of cable, factory-packaged in containers or on reels. Storage of all components shall be provided including rental of containers or other suitable methods as specified.

H. Fire Protection:
1. Use only fire-rated cables in accordance with USA NEC in all plenum and vertical riser spaces. Employ CMP-rated cable in air plenums and CMR-rated cable in risers. Where a cable passes both vertically and through air plenum spaces, the entire cable shall be rated CMP. The cable may not be applied.

I. Fire Stopping:
1. Use fire stop methods and materials that are FM approved and UL listed as applicable and approved by the authorities having jurisdiction. Suitably fire stop all riser shaft openings; horizontal sleeve penetrations, both ends of any horizontal conduits and all slot cuts in wall and under raised access floors which are needed to facilitate cable access/egress.
2. During construction phase, fire-stopping pillows are required. If pillows are approved as a permanent solution either by the Fire Marshall or local jurisdiction, they may remain as a permanent solution. If pillows are not approved as a permanent solution, contractor shall seal all tel data penetrations with an approved fire stopping solution.
3. Verify to the Architect's satisfaction that the integrity of all fire stops is maintained upon completion of the work.
4. Fire stop all openings through fire rated structures (i.e. wall, partitions, pressurized access floors, etc.) throughout the facility upon completion of cabling.

J. Protection/Restoration of Premises:
1. As required, during the progress of work, remove and properly dispose of resultant dirt and debris, hang protective plastic sheathing when specified and keep premises clean. Upon completion of work, remove equipment and unused material provided for work.

K. Quality Assurance:
1. Contractor shall be Corning Cable Systems Certified.
2. Contractor shall be certified to warranty the Panduit structured cabling system, end-to-end for a period of twenty (20) years. This will include all Contractor supplied components, including but not limited to wire, termination connections and panels. And the fitness of the system to carry Ethernet traffic through Gigabit/sec speeds as specified above.
3. The work shall be executed in full accordance with the current rulings of the latest applicable standards and all rulings by state, utility, and local authorities. Where codes conflict, the more stringent shall apply. Where the specification requirements exceed the requirements of these authorities, codes and standards, the specification requirements shall prevail.

4. Replace any imperfect or rejected work with work conforming to the requirements of the specification and shall be satisfactory to the Architect without extra cost to the authority.
5. Report to the General Contractor and Architect promptly in writing whenever plans or specifications are believed to be at variance with these requirements and shall not proceed with such work until further instructed in writing.

L. Fiber Optic Cable Plant Installation:
1. See T plans for installation details.

M. Copper Cable Plant Installation:
1. The drawings show the copper cable plant layout and associated required. All riser copper cable shall be terminated in connectors/blocks/patch panels as specified in the drawings and specifications.
2. All station cable will be mounted on blocks, patch panels, and wall jacks as shown on drawings.
3. Install copper cable in accordance with manufacturer's specifications. Do not exceed the maximum pulling tension or bend radius of the cable.
4. Provide all materials for installation including but not limited to splice cases, racks, patch panels, jacks, wall plates, and connectors.

N. Coax Cable Plant:
1. Not Used.

O. Racks, Cables, Connectors, and Miscellaneous Equipment:
1. Wiring and Interconnections:
    a. General:
        1) Exercise care in wiring to avoid damage to cables and equipment.
        2) All wiring executed in strict adherence to standard telecommunications practices. This includes:
            a) Dress cables in conveniently sized bundles, combed into parallel runs.
            b) Install Velcro wraps loosely, do not deform the cables, at 1 foot intervals for support of cables at all equipment racks.
            c) Organize cables and cable bundles behind patch bays to permit easy access to the patch panels to add or remove cables.
            d) Install quantities of empty data patch panels and modular inserts to terminate all horizontal cables distributing from IDF plus 20%.
            e) All data cat6/6A horizontal cables are to be terminated on the patch panels. The cables are to be cut down numerically in ascending order starting from the upper left port, left to right, top to bottom.
            f) Place cable markers 3"-5" back from connectors to permit easy viewing. Do not bind markers into cable bundles.
            g) No horizontal cable run shall exceed 90 Meters or 295 feet including slack.
    b. Equipment Racks and cabinets:
        1) Each rack or cabinet shall house equipment and devices of the following in various quantities:
        2) Electronic equipment provided by others (coordinate with owner).
        3) Communication patch panels.

4) Horizontal and vertical cable management panels.
5) All racks shall be properly grounded directly to the TGB or TMGB and not to overhead tray or ladder racking. All racks or cabinets shall be grounded conforming to ANSI/TIA/EIA 607-B, NEC and all related grounding standards and codes.
6) Provide unused panel spaces with blank panels in cabinets to completely close up front and back of cabinet.

c. Receptacles:
1) CIT standard color is electric ivory.
2) Floor-mounted receptacles in flush floor boxes with flush lids.
3) Wall phones shall be mounted 48" aff for handicap locations.

d. Data for Wireless Access Points
1) Install and test cat6A data modular insert in a 4" electrical back box finished flush to ceiling with a double gang plaster ring. Connect with one inch conduit to nearest accessible ceiling. Terminate the cable at box with 6" - 8" tail without faceplate.
2) Install wireless access point bracket, provided by CIT, over the electrical back box.

2. D-Rings and Bridle rings
a. Install plastic D-rings horizontally between termination panels at the beginning of every section of the termination pane.
b. Install D-rings vertically 2 feet on center around the communications closet at the top edge of the plywood.
c. Cable caddy's rings shall be installed every 3' on center from the accessible ceilings in the corridor to the vertical EMT installed at each outlet.
d. EMT sleeves should be used to access the corridor and firestopped (removable) as required. Plastic bushings must be installed on each end of the EMT sleeve.
e. The routing of these Bridle Rings must be as straight as possible and installed in a secure manner – to be approved by Owner' Representative.

2.3 LABELS

A. Identify all outlets, and terminal blocks and patch panel ports with machine made, unique identifier label. The communication cables shall also have same label fixed to the cable within 4" of end of cable, both ends. The contractor is required to follow the CIT numbering scheme as indicated in these specifications and on the IT drawings.

B. Labeling scheme is as follows:
a. 4023-A
b. 4023 Represents the room number
c. A Represents the jack letter

C. Identify all cables terminating at patch panel with the work area outlet room name and jack number; as shown on drawings to distinguish multiple cables terminating at the same outlet.

D. Communications and data conduit are to be clearly identified at every junction box via a painted section or by use of conduit stickers indicating each conduit run.

E. Room numbers appear on the contract documents for reference only. All labels shall reflect the Owner's final room designations.

F. Submit sample label for approval with shop drawings.

2.4 COLOR CODING

A. Originating and terminating points of a group of wire pairs will be connected to color coded hardware. CIT uses the following color codes.
   a. ORANGE - Demarcation Point
   b. GREEN – station cables
   c. GREEN – Outside plant cabling shall be taped with Green electric tape. Outside plant wall field shall be painted GREEN.
   d. BLUE – Riser backbone cabling shall be taped with BLUE electric tape. Riser backbone wall field shall be painted BLUE.

2.5 TESTING AND ACCEPTANCE:

A. General Instructions:
   1. Coordinate exact test procedures with Panduit.
   2. Thoroughly test all cables and connectors installed. The Architect requires certification that all cables were tested and found to be 100% reliable end-to-end (block-to-block and block-to-receptacle); bad pairs/punch-downs and/terminations shall not be used, but rather be corrected and/or replaced at no additional cost. All cables are expected to meet or exceed standards for Category 6/6A unshielded twisted pair cable, for single mode fiber, and for multi-mode fiber cable as specified in TIA/EIA568-C.1.
   3. Provide (1) electronic copy of all completed test reports organized by DF room. Provide (1) hard copy of all test data organized by DF with O and M manuals. Submit these test reports to the Architect for approval. Once all test results are approved, final results are provided to the owner for their record.

B. Acceptance Testing:
   1. Perform the tests and inspections described in this section in the presence of the Architect or their representative. Each floor and closet shall be tested individually and accepted on a per floor basis. The cabling system shall be tested for compliance with the specifications for physical placement, electrical specifications, wiring accuracy, continuity, and proper labeling and identification. Document all test results.
   2. Upon approval of the contractor's test report, and at a time set by the Owner or Owner's authorized representative, assist in performing final system adjustments and acceptance tests. Provide all labor, material, tools, and measurement equipment necessary for these tests and adjustments, including the test equipment and material specified above, except as otherwise specified.
   3. Acceptance testing shall include:
      a. Plant installation.
      b. Review of test documentation
      c. Proper placement of cable
      d. Grounding
      e. Protection (lightning)
      f. Coring and wall penetration including proper fire stopping
      g. Any other requirements of the contract.
   4. In addition to the above, the client shall also perform an inspection of the equipment rooms, risers, etc., for cleanliness, labeling, and overall compliance.
   5. The Owner shall also test at random assorted installations for overall operation, installation, labeling, etc.

C. The contractor performing the tests shall be thoroughly trained with the test equipment and cat 6 and fiber optic cabling systems.

D. Testing Procedures:
1. Provide the necessary test equipment to conduct the tests.
2. Field tests may be required to be performed in the presence of the Architect and/or its duly authorized representatives. Provide written documentation reporting the results of all tests.

E. Pre-Installation Testing:
1. Obtain factory test data for each reel of cable including, but not limited to:
   a. Physical Production Tests (tensile strength);
   b. Transmission Production Tests
   c. To ensure that all specifications and standards are maintained within manufacturer's specifications, provide to the Architect the Manufacturer's Test Certification for each reel of cable.

F. Physical Inspection:
1. Prior to the conduct of any transmission testing, the following visual inspections shall be performed:
   a. Verify that cable has been installed to comply with contract documents.
   b. Check for physical damage to Distribution Panels and Termination Blocks.
   c. Verify that outlets have been securely mounted and properly labeled.
   d. Check that all cabling is properly jacketed, installed and labeled at both ends (to the appropriate block/panel in the closet and IDF);
   e. Verify that all cable bends are within the manufacturer's minimum bend radius allowed;
   f. Check and demonstrate that all cable shields have been correctly grounded or bonded;
   g. Verify that the cable is properly supported for termination and long term placement (approvals must be obtained from the Architect);
   h. Verify that all cables are properly supported and independent of any other support/hanger rods in the ceiling space.
2. Verify that cables have been terminated properly and in proper color code sequence.

G. Fiber Optic Cable Test Procedures
1. Test single mode fiber optical strands at 1310 and 1550 nm using a light source and meter from the MDF.

H. Data Copper Cable:
1. All locations shall be tested after installation and a written accounting identifying the test results should be maintained by Bidder and delivered to the Owner.
2. All horizontal cables shall be permanent link tested per ANSI/TIA 568C.
   a. line map continuity
   b. length
   c. Link Insertion Loss (formally attenuation) less than 31.0 dB @ 250 MHz.
   d. Link NEXT/FEXT Pr. to Pr. greater than 38.3 dB @ 250 MHz.
   e. Link NEXT/FEXT PWR. greater than the sum 32.7 dB @ 250 MHz.
   f. Link ELFEXT Pr. to Pr. greater than the sum 16.2 dB @250 MHz.
   g. Link ELFEXT PWR greater than sum 13.2 dB @ 250 MHz.
   h. Return loss 10.0 dB @ 250 MHz.

3. Telecommunications installer shall utilize Level III link cable tester with manufacturer's latest version of firmware installed.
4. Installer to coordinate with test equipment manufacturer for exact test procedures for Systimax Link, Berk-Tek, Superior Essex and Panduit testing
5. Replacement:
6. Any cable, connector, or block which tests below manufacturer's standards shall be replaced at no additional cost. The replacement shall be re-tested to verify compliance.
7. Successful completion of all tests indicated below is required for acceptance.

I. "Acceptance Date" shall be defined as the date upon which the installation has passed all acceptance tests, all punch list items are completed, and all post-cut-over documentation is received and the Owner delivers Notice of Acceptance of the installation to the Bidder.

J. Final payments to the Bidder shall not be released until after all items are completed and not prior to the Acceptance Date.

2.6 OPERATION AND MAINTENANCE MANUALS

A. Operation and Maintenance - Coordinate with Section 01700
1. Functional Diagrams: Simplified single line block diagram showing interconnection of all major equipment components and functional relationships. Key each patch panel to the patch bay by row and jack number. Diagram shall illustrate terminal or interconnection cable number designations. As-Built Diagrams:
   a. The intent of the diagrams is to provide sufficiently clear and complete information that a technician of average skill may efficiently troubleshoot and service the system, even if unfamiliar with the installation.
   b. Provide drawings showing all terminal blocks, connectors, equipment components, and wires. Label all devices with manufacturer, model number, and reference number (e.g. "SW 15", "TB 6"); reference numbers shall be consistent across all drawings with no repetitions. As a minimum, provide an expanded version of the functional diagrams with cables fanned out at termination points and all labeling as specified above; provide additional drawings where system complexity does not permit complete information to be shown legibly on an individual sheet no larger than the project sheet size. Provide labels for cables continued onto another drawing, indicating termination device, terminal numbers, and drawing sheet on which the termination is shown.
   c. Provide layout drawings of panels and other custom assemblies containing switches, hubs, routers, relays, etc., using reference numbers to identify physical locations of devices or label devices with reference numbers in a location visible while viewing cable terminations. On wiring diagrams, label all conductors within cables for insulation color or other identifier. Label connectors, barrier strips, switches, etc., for terminal number. If device does not provide terminal designations, provide key diagram for reference.
2. Receptacle Location Plan: Plan of area showing locations and designations of all receptacles.
3. Patch Panel Assignment Schedule: Mount a typed schedule of patch panel assignments behind acrylic at the equipment racks.

4. Complete Instruction and Maintenance Manual: Prepare in the form of an instructional manual for use by Owner's personnel. Provide one (1) draft copy within one month of substantial completion and two (2) final copies two weeks after approval of draft unless otherwise specified.
5. Format:
   a. Size: 8-1/2" x 11", 20 lb. minimum weight white paper for typed pages, either manufacturer's printed data, or neatly typewritten.
   b. Drawings: Provide reinforced punched binder tab, bind in with text. Fold larger drawings to size of text pages. Clear plastic "binding tape" (not "Scotch" tape) applied to edge of sheet and then punched is acceptable.
   c. Single-sheet product literature and contractor-prepared pages: Provide reinforced punched binder tab. Clear plastic "binding tape" (not "Scotch" tape) applied to edge of page and then punched is acceptable.
   d. Provide indexed tabs and flyleaf for each separate product, or each piece of operating equipment. Include typed description of product, and major component parts of equipment.
   e. Cover: Identify each volume with typed or printed title "OPERATING AND MAINTENANCE INSTRUCTIONS".
   f. Binders:
   g. Commercial quality three-ring binders with durable and cleanable plastic covers, 1" minimum, 2" maximum ring size.
   h. When multiple binders are used, collate the data into related consistent groupings.
6. Content of Manuals:
   a. Neatly typewritten table of contents for each volume, arranged in systematic order. Identify each product by product name and other identifying symbols as set forth in Contract Documents.
   b. Contractor, name of responsible principal, address and telephone number.
   c. Certificate of Warranty for the system as a whole as well as copies of the manufacturer’s warranty for each equipment item.
   d. Service Contract. Provide a service contract to the Owner for those systems items installed that will require periodic servicing. Include costs and preliminary schedules.
   e. Complete as-built diagrams for systems.
   f. Receptacle Location Plan.
   g. Patch Panel Assignment Schedule.
   h. Building Plan.
   i. Original copies, high-quality laser printer printouts of PDF files, or high-quality photocopies of manufacturers' installation, operation, and service manuals, for each equipment item.
   j. Shop drawings of all custom-fabricated items.

B. If requested, available computer-drawn (CAD) bid drawings are provided in .DWG or DXF compatible format to assist the contractor in producing the required submittal and shop drawings. Upon request, bid drawings will be available in electronic form. Requests must include the project name, project number, drawing numbers and type of files requested. Requests should be forwarded to architect.

C. Quality Assurance

1. The Owner shall conduct regular inspections of all construction and installation work under the control of the Contractor. The Owner shall generate punch lists, noting any and all deficiencies in the installation of the Cabling Systems. A copy of the punch list will be provided to the General Contractor for correction. The punch list will be accompanied by statements specifying what actions will be taken to resolve open issues as well as target dates for the resolution of problems on the punch list.
2. Inspect each reel of cable for physical damage. Any reel or cable container found to be damaged to the extent that cable integrity may be affected shall be returned to the supplier for replacement.
3. Prior to installation inspect all hardware (distribution shelves, connectors, etc.). Replace any damaged or faulty equipment.
4. The failure of Owner to observe damaged or faulty installations or equipment shall not relieve Contractor of obligation to correct such damage or fault.
5. The owner will coordinate with the various trades the location of all core holes and wall penetrations.
6. A copy of CIT cable pull schedule format will be provided to the contractor. The contractor shall use this format for as built documentation.

D. Materials and Equipment List: Contractor shall include all the approved shop drawings that were submitted in the submittal process in the O and M manual. This will include data sheets with the indicating arrows, complete catalog identification numbers and models or system designator, quantities, options and catalogs "cuts."

E. Documentation: Provide operation, maintenance and service manuals for systems and equipment provided under this contract prior to final acceptance of the system. The manuals shall include the following:
1. Complete maintenance instructions and wiring diagrams.
2. Complete parts list.
3. Manufacturer's warranties.
4. Complete technical specifications for the system and all components.
5. Name, address and telephone number for system service.

F. Record Drawings: Provide and keep up-to-date a complete record set of drawings which shall be corrected and shall show every change from the original specifications and Contract Drawings.

G. Bidder shall provide to Owner all required warranties, parts lists, plans, operating manuals, etc., prior to acceptance testing. All of the above shall be updated as required for as long as the system is in service.

H. The manuals shall identify project and include the name and address of Contractor and major Sub Contractors.

I. Documentation must include the Manufacturer's Certificate of Warranty for all components. Warranty shall be obtained for at least one (1) year.

2.7 CABLE SYSTEM DOCUMENTATION

A. General Instructions:
1. Contractor to provide as-built cable schedule in excel spreadsheet and cable plans to Cornell CIT four weeks prior to occupancy for service activation planning.

2. Provide documentation enumerating termination panels and every cable run. Supply any additional documentation not explicitly listed, which should be provided to facilitate a complete, working installation prior to acceptance.
3. Provide documentation of all installed cable in an electronic database.

B. Submit shop drawings for review before procurement, fabrication, or delivery of such items to the job site. Partial submittals are not acceptable. Such submittals shall be returned without review.
1. Manufacturer's Data: Submittals for each manufactured item shall be manufacturer's descriptive literature, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts. Each submittal shall include the manufacturer's name, trade name, catalog model or number, nameplate data, size, layout dimensions, capacity, specification reference, applicable Federal and industry specification references, and all other information necessary to establish Contract compliance.
2. Shop Drawings: Shop drawings shall show types, sizes, accessories, elevations, floor plans and sectional views. Points to point wiring diagrams are required. Drawings shall also indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.
   a. If any equipment is nonconforming, the drawings shall be revised to show acceptable equipment and be resubmitted.
3. Standard Compliance: Materials or equipment are required to conform to the standards or organizations such as National Electrical Manufacturers Association (NEMA), or Underwriters Laboratories (UL).
4. Certified Test Reports: Before delivery of materials and equipment, certified copies of all test reports specified in the individual section shall be submitted for approval.

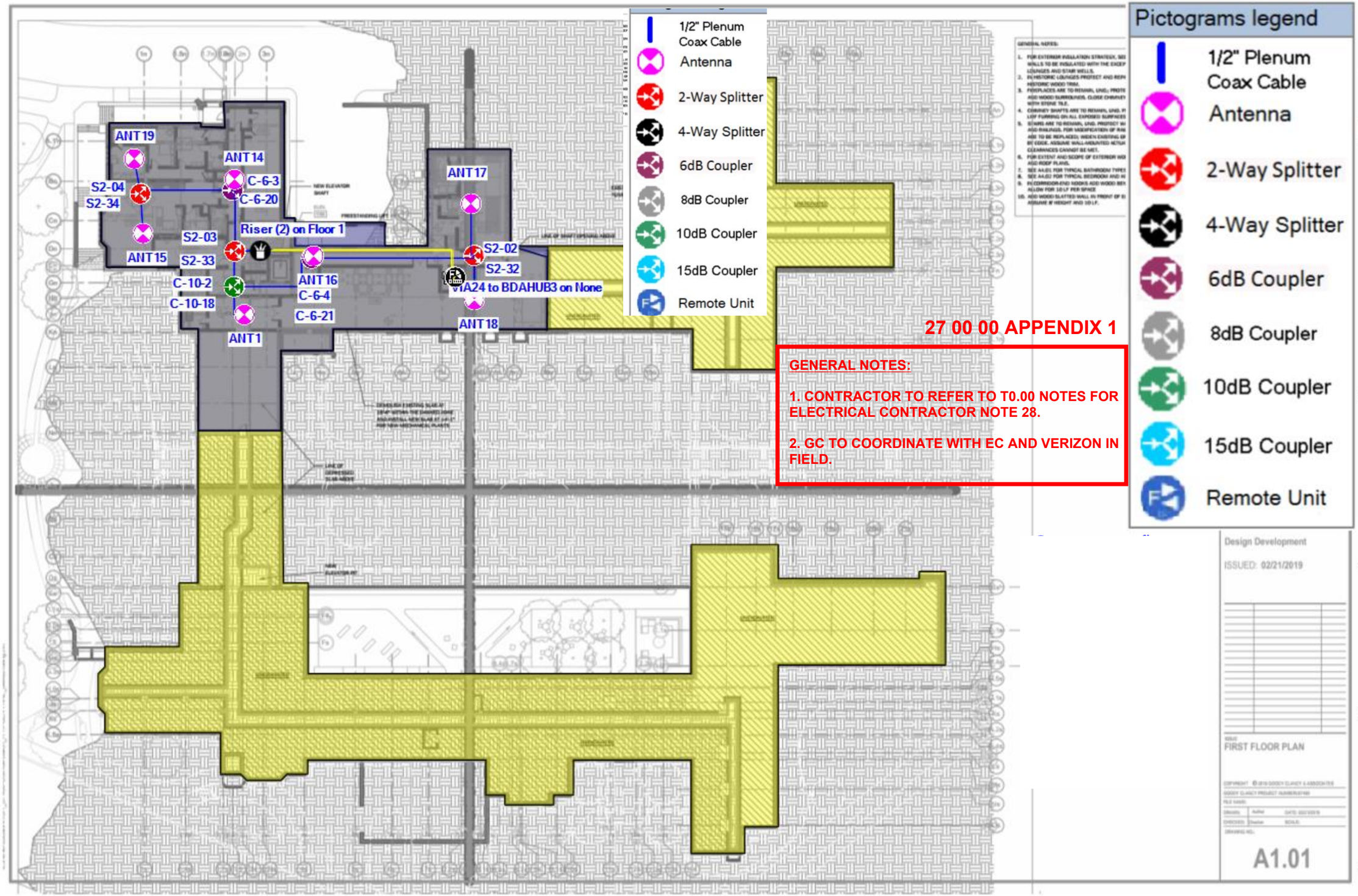
C. Cable Management
1. Supply records for the pull schedule, and cross-connect schedules in MS Excel.
2. Provide documentation for tracing of individual strands/conductors through all intermediate terminations from end to end.

2.8 CLEANING

A. Clean up each work area at the end of the day. Remove all cartons, debris, emptied containers, etc. as the work progresses, and finally at completion of the work of this Section.

B. Just prior to inspection for substantial completion perform all final cleaning and sealing of equipment required to bring the installation to optimum appearance.

END OF SETION 27 00 00



27 00 00 APPENDIX 1

GENERAL NOTES:

1. CONTRACTOR TO REFER TO T0.00 NOTES FOR ELECTRICAL CONTRACTOR NOTE 28.

2. GC TO COORDINATE WITH EC AND VERIZON IN FIELD.

Pictograms legend

- 1/2" Plenum Coax Cable
- Antenna
- 2-Way Splitter
- 4-Way Splitter
- 6dB Coupler
- 8dB Coupler
- 10dB Coupler
- 15dB Coupler
- Remote Unit

Design Development

ISSUED: 02/21/2019

FIRST FLOOR PLAN

A1.01

C² Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

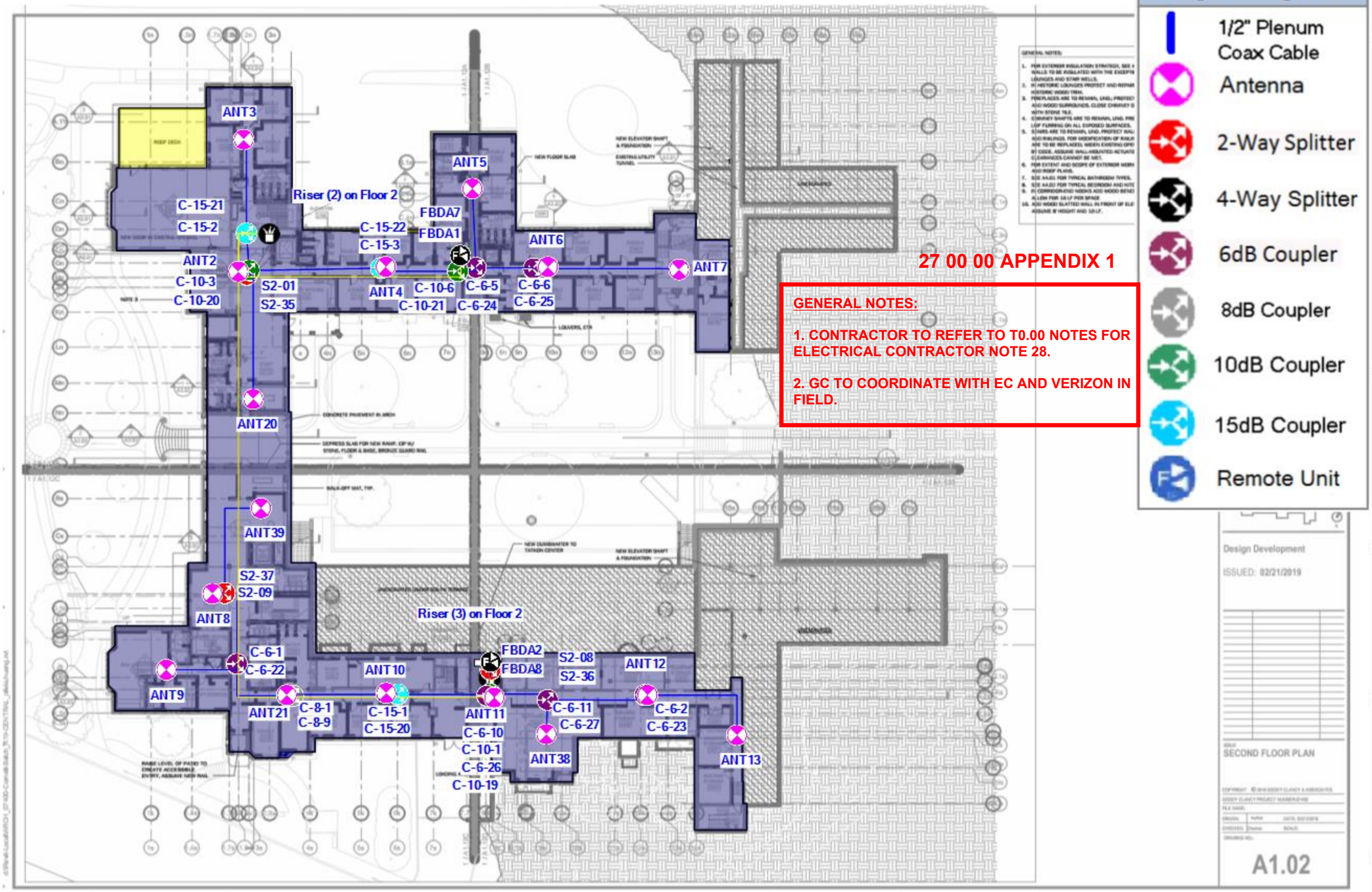
Greg Tobias

Plan name

Floor 1

Date

6/22/2020



27 00 00 APPENDIX 1

GENERAL NOTES:

1. CONTRACTOR TO REFER TO T0.00 NOTES FOR ELECTRICAL CONTRACTOR NOTE 28.
2. GC TO COORDINATE WITH EC AND VERIZON IN FIELD.

Pictograms legend

- 1/2" Plenum Coax Cable
- Antenna
- 2-Way Splitter
- 4-Way Splitter
- 6dB Coupler
- 8dB Coupler
- 10dB Coupler
- 15dB Coupler
- Remote Unit

Design Development

ISSUED: 02/21/2019

SECOND FLOOR PLAN

A1.02

C Squared Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

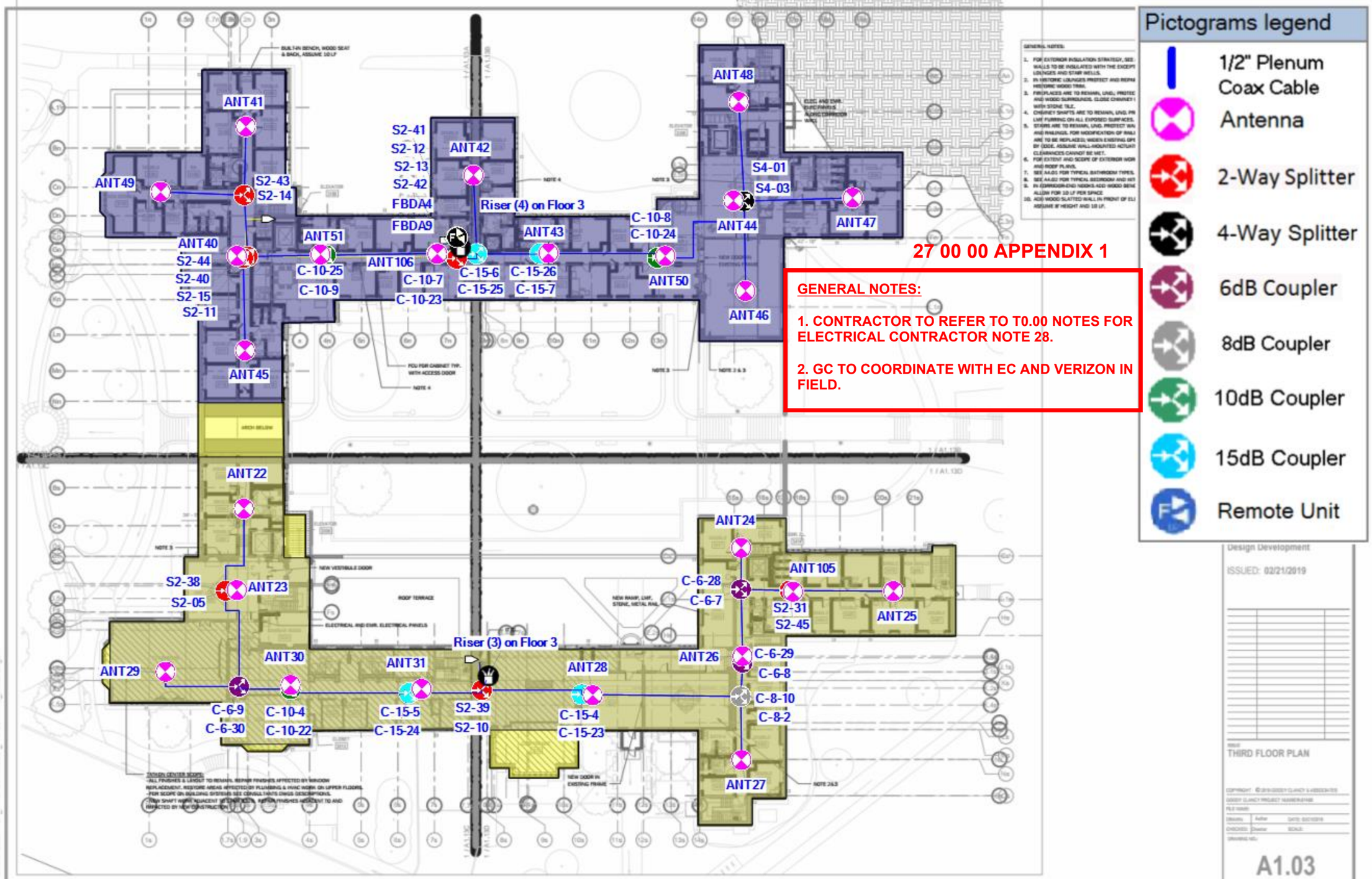
Greg Tobias

Plan name

Floor 2

Date

6/22/2020



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Pictograms legend

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- 8dB Coupler
- 10dB Coupler
- 15dB Coupler
- Remote Unit

Design Development

ISSUED: 02/21/2019

THIRD FLOOR PLAN

A1.03

C Squared Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

Greg Tobias

Plan name

Floor 3

Date

6/22/2020

ANT53
ANT62
S2-48
S2-18
Riser (4) on Floor 4
Riser (2) on Floor 4
ANT52
S2-49
S2-46
S2-19
S2-16
C-10-11
C-10-27
ANT64
ANT55
S2-47
C-15-8
C-15-28
ANT54
C-15-27
C-15-9
ANT56
C-15-10
C-15-29
ANT63
C-10-10
C-10-26
ANT61
S4-04
ANT57
ANT60
ANT59
ANT58
ANT77
S2-53
S2-23
ANT65
C-6-33
C-6-14
ANT66
C-6-32
C-6-13
ANT73
ANT72
C-10-13
C-10-29
ANT74
C-15-30
C-15-11
S2-52
S2-22
FBDA6
FBDA10
C-15-12
C-15-31
ANT71
C-10-28
C-10-12
ANT75
ANT69
ANT76
ANT67
C-6-34
C-6-15
S2-50
S2-20
ANT68
C-6-31
S2-51
C-6-12
S2-21
ANT70

27 00 00 APPENDIX 1

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Pictograms legend

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- 8dB Coupler
- 10dB Coupler
- 15dB Coupler
- Remote Unit

Design Development

ISSUED: 02/21/2019

FOURTH FLOOR PLAN

A1.04

C Squared Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

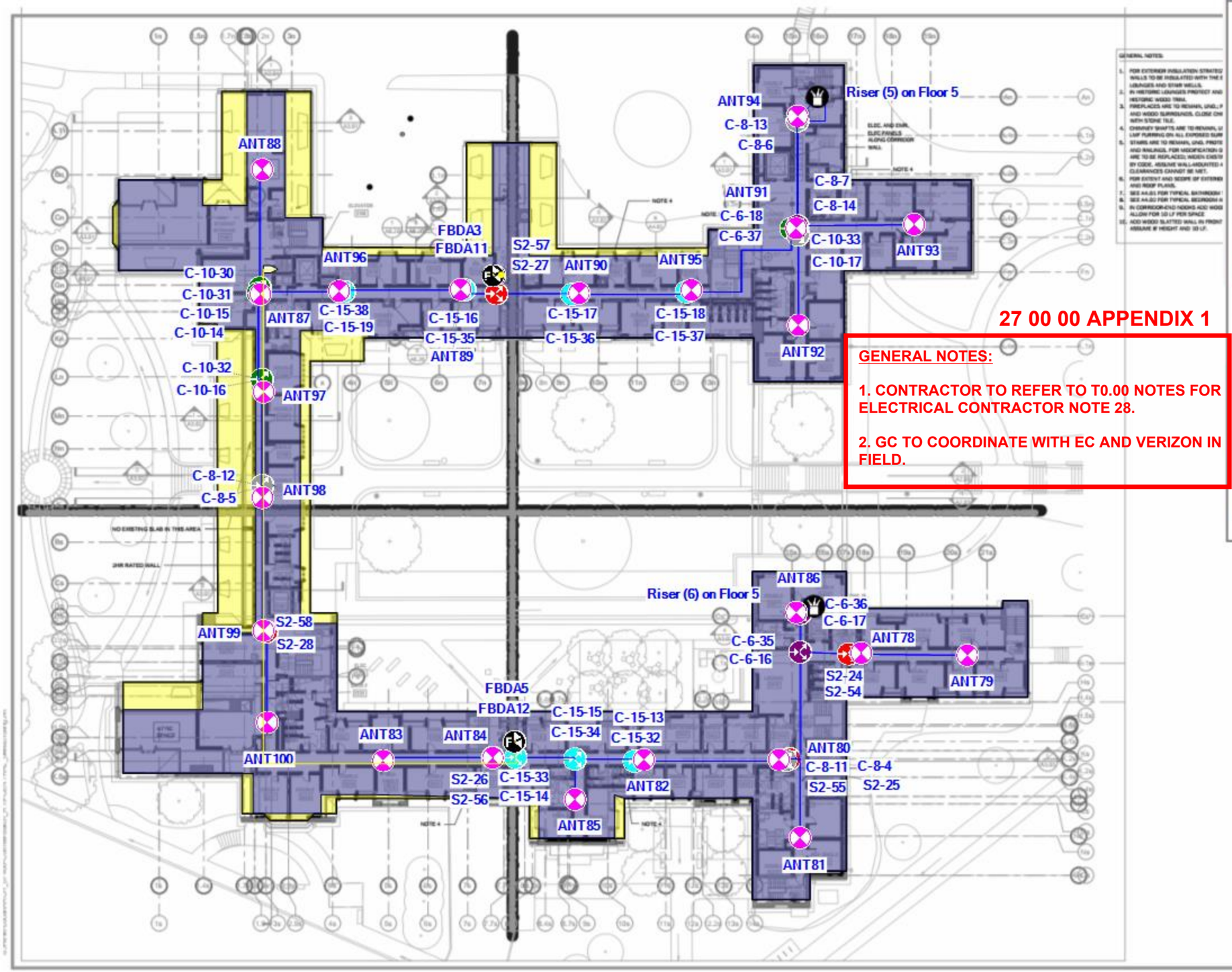
Greg Tobias

Plan name

Floor 4

Date

6/22/2020



27 00 00 APPENDIX 1

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2. GC TO COORDINATE WITH EC AND VERIZON IN FIELD.

Pictograms legend

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- 4-Way Splitter
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- 8dB Coupler
- 10dB Coupler
- 15dB Coupler
- Remote Unit

Design Development

ISSUED: 02/21/2019

FIFTH FLOOR PLAN

A1.05

C Squared Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

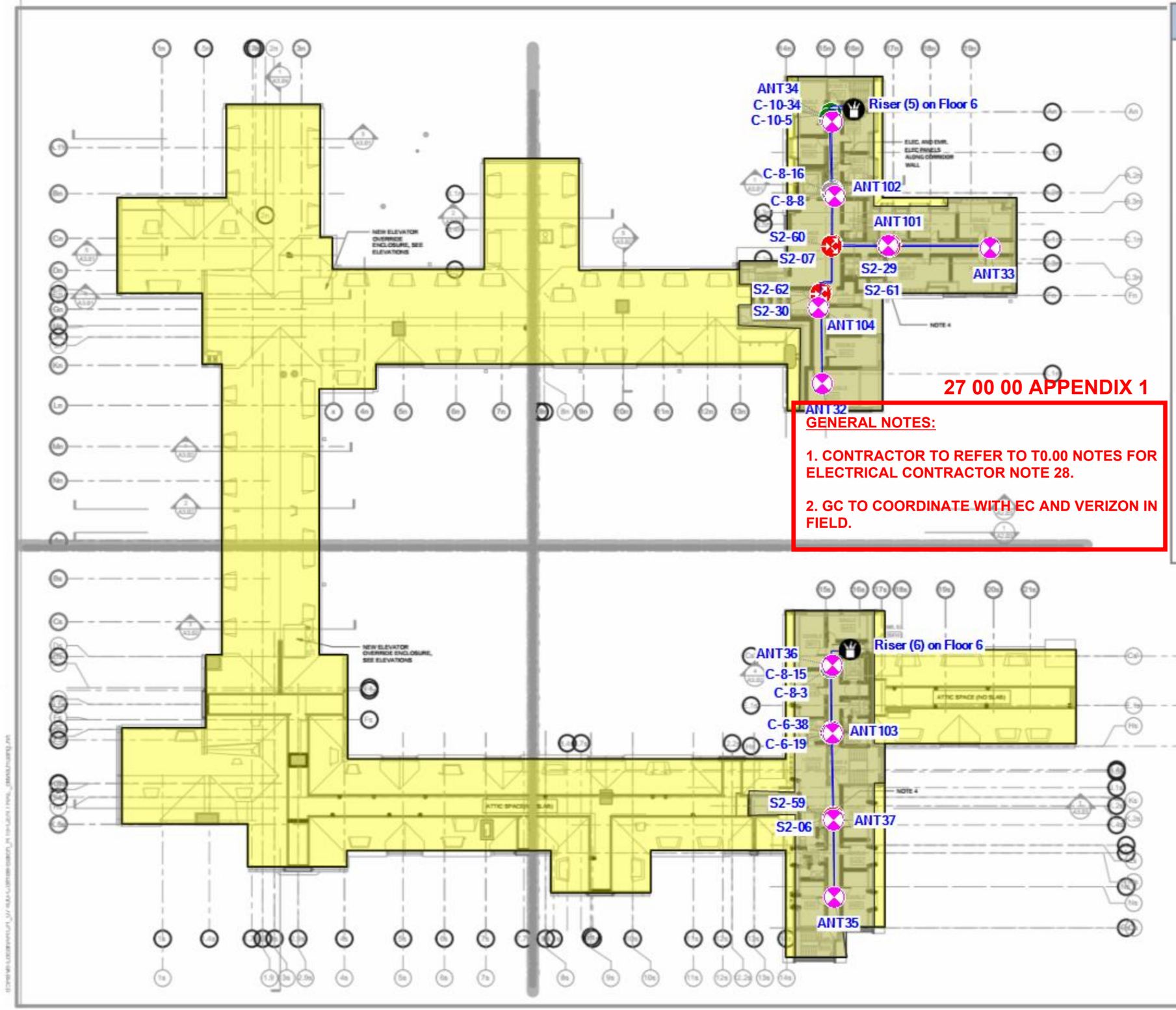
Greg Tobias

Plan name

Floor 5

Date

6/22/2020



27 00 00 APPENDIX 1

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2. GC TO COORDINATE WITH EC AND VERIZON IN FIELD.

Pictograms legend

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- Antenna
- 2-Way Splitter
- 4-Way Splitter
- 6dB Coupler
- 8dB Coupler
- 10dB Coupler
- 15dB Coupler
- Remote Unit

C² Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

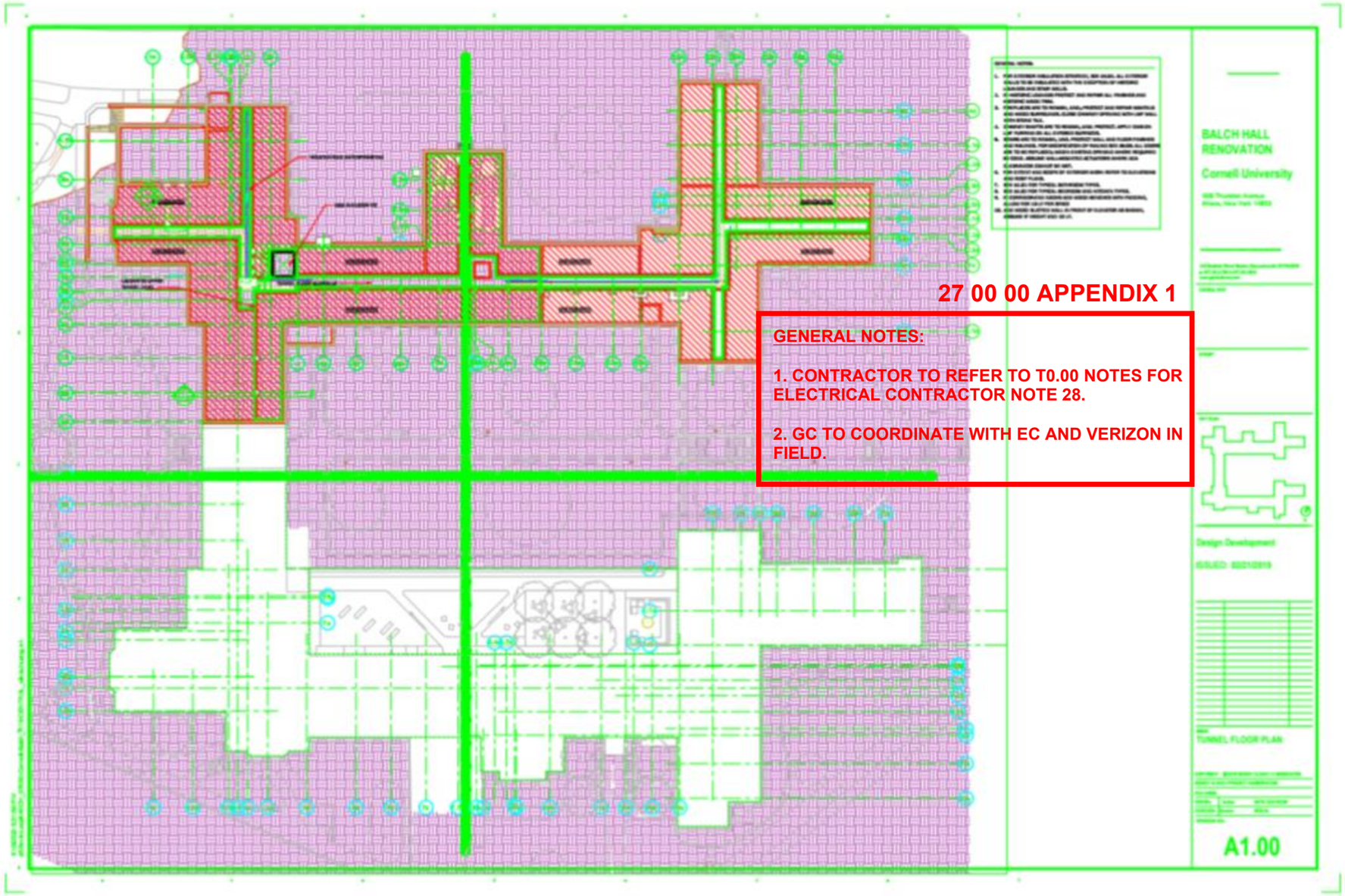
Greg Tobias

Plan name

Floor 6

Date

6/22/2020



27 00 00 APPENDIX 1

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2. GC TO COORDINATE WITH EC AND VERIZON IN FIELD.

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

Greg Tobias

Plan name

Tunnels

Date

6/22/2020

Design Notes for Cornell University - Balch Hall

Design is a MIMO neutral host system for AT&T, T-Mobile and Verizon. The power sharing is an even split between the three.

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All antennas were modeled to be above ceiling. Antenna mounts were accounted for in the BOM. Main Headend equipment not account for in the BOM because it is already built on site.

The tunnel layout is added but not designed for. We will design it once we know the customer would like this area to be covered.

Estimated square footage of building is 152,384 square feet .

Design has 106 antennas and 12 remotes throughout.

27 00 00 APPENDIX 1

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2. GC TO COORDINATE WITH EC AND VERIZON IN FIELD.

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

Greg Tobias

Plan name

Design Notes

Date

6/22/2020

27 00 00 APPENDIX 1

GENERAL NOTES:

1. CONTRACTOR TO REFER TO T0.00 NOTES FOR ELECTRICAL CONTRACTOR NOTE 28.

2. GC TO COORDINATE WITH EC AND VERIZON IN FIELD.

Venue	Balch Hall	
Address	600 Thurston Ave, Ithaca NY	
State	New York	
County	Tompkins	
Latitude	N 42.452988	
Longitude	W 76.480260	
Venue AMSL	820 ft	
Site Contacts	Amanda Sanders	
Venue Special Access/Security	Contact Amanda Sanders	
700 MHz Spectrum	Upper C	
700 MHz Bandwidth	10 MHz	
1900 MHz Spectrum	C1	
1900 MHz Bandwidth	5 MHz	
1700/2100 MHz Spectrum	AB	
1700/2100 MHz Bandwidth	20 MHz	
Approximate Coverage Area	152,385 Square Feet	
Coordinate Source	Mapping Software	
System Type	Active, MIMO	
Fiber DAS Equipment (MFG and Model)	Teko - TRX7E8AE19HAWX23AT	
Main Head End Equipment Location	C.C.C First Floor Telephone Room 120	
Local Head End Equipment Location	First Floor MDF 1109	
Number of Remotes	12 (6 SISO, 6 MIMO)	
Fiber Remote Locations	FBDA1&7	Floor 2 Northside IT Closet
	FBDA2&8	Floor 2 Southside IT Closet
	FBDA3&11	Floor 5 Northside IT Closet
	FBDA4&9	Floor 3 Northside IT Closet
	FBDA5&12	Floor 5 Southside IT Closet
	FBDA6&10	Floor 4 Southside IT Closet
Fiber Type	Lit Fiber	
Number of Interior Antennas	106	

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

Greg Tobias

Plan name

Overview table

Date

6/22/2020

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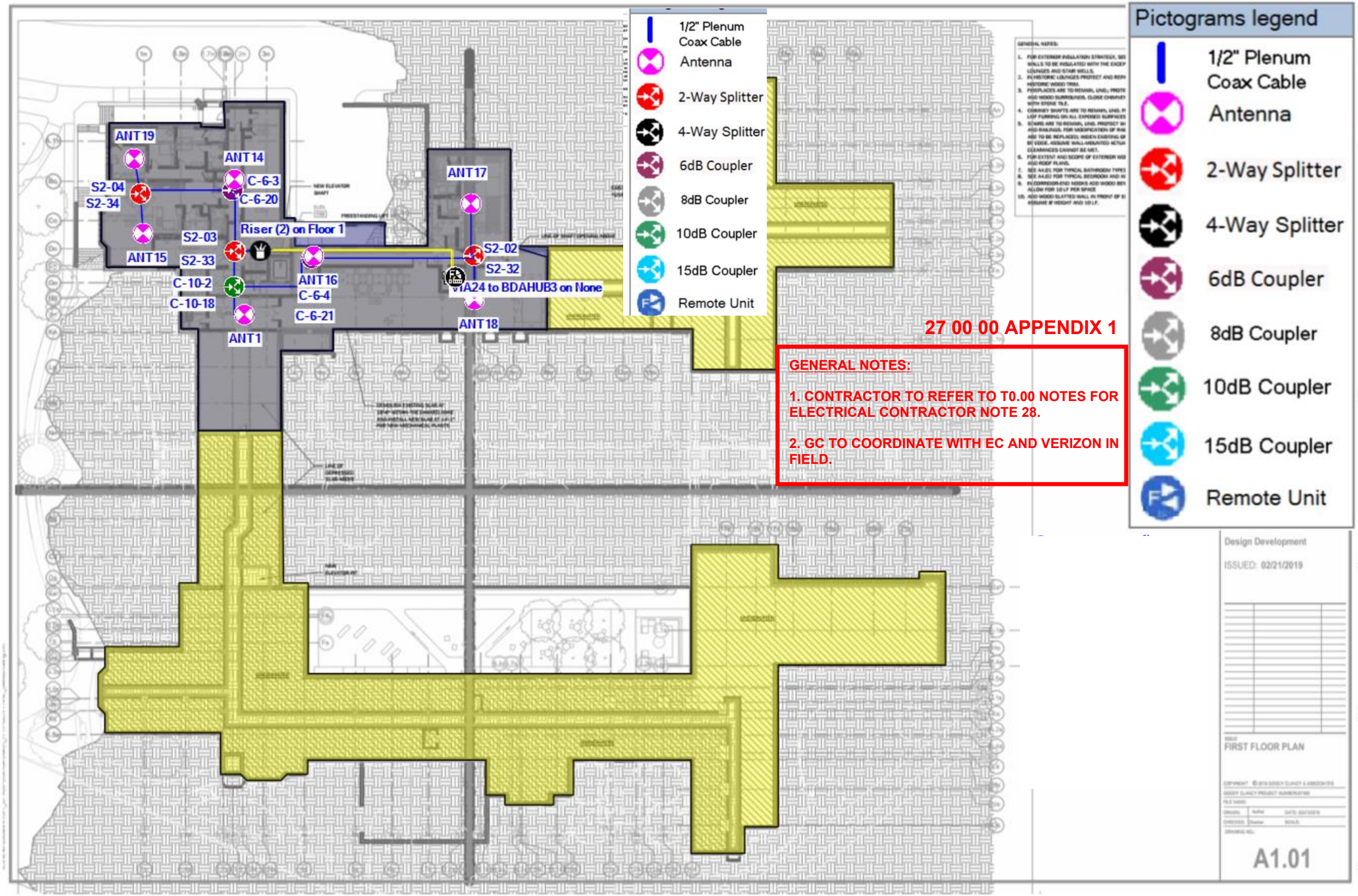

27 00 00 APPENDIX 1

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2. GC TO COORDINATE WITH EC AND VERIZON IN FIELD.

Pictograms legend

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- Antenna
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- 4-Way Splitter
- 6dB Coupler
- 8dB Coupler
- 10dB Coupler
- 15dB Coupler
- Remote Unit

Design Development

ISSUED: 02/21/2019

FIRST FLOOR PLAN

A1.01

C² Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

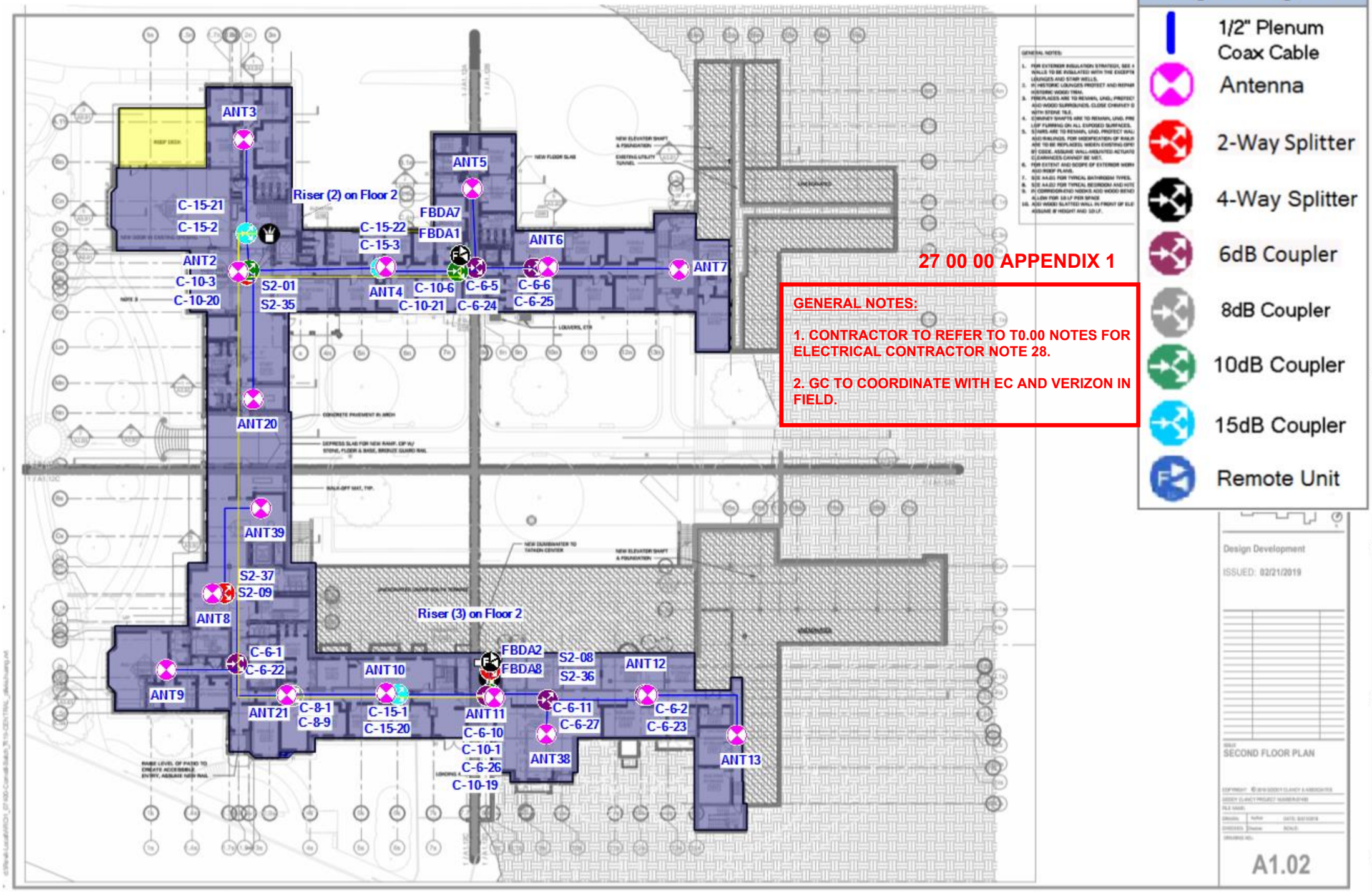
Greg Tobias

Plan name

Floor 1

Date

6/22/2020



27 00 00 APPENDIX 1

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- 10dB Coupler
- 15dB Coupler
- Remote Unit

Design Development

ISSUED: 02/21/2019

SECOND FLOOR PLAN

A1.02

C Squared Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

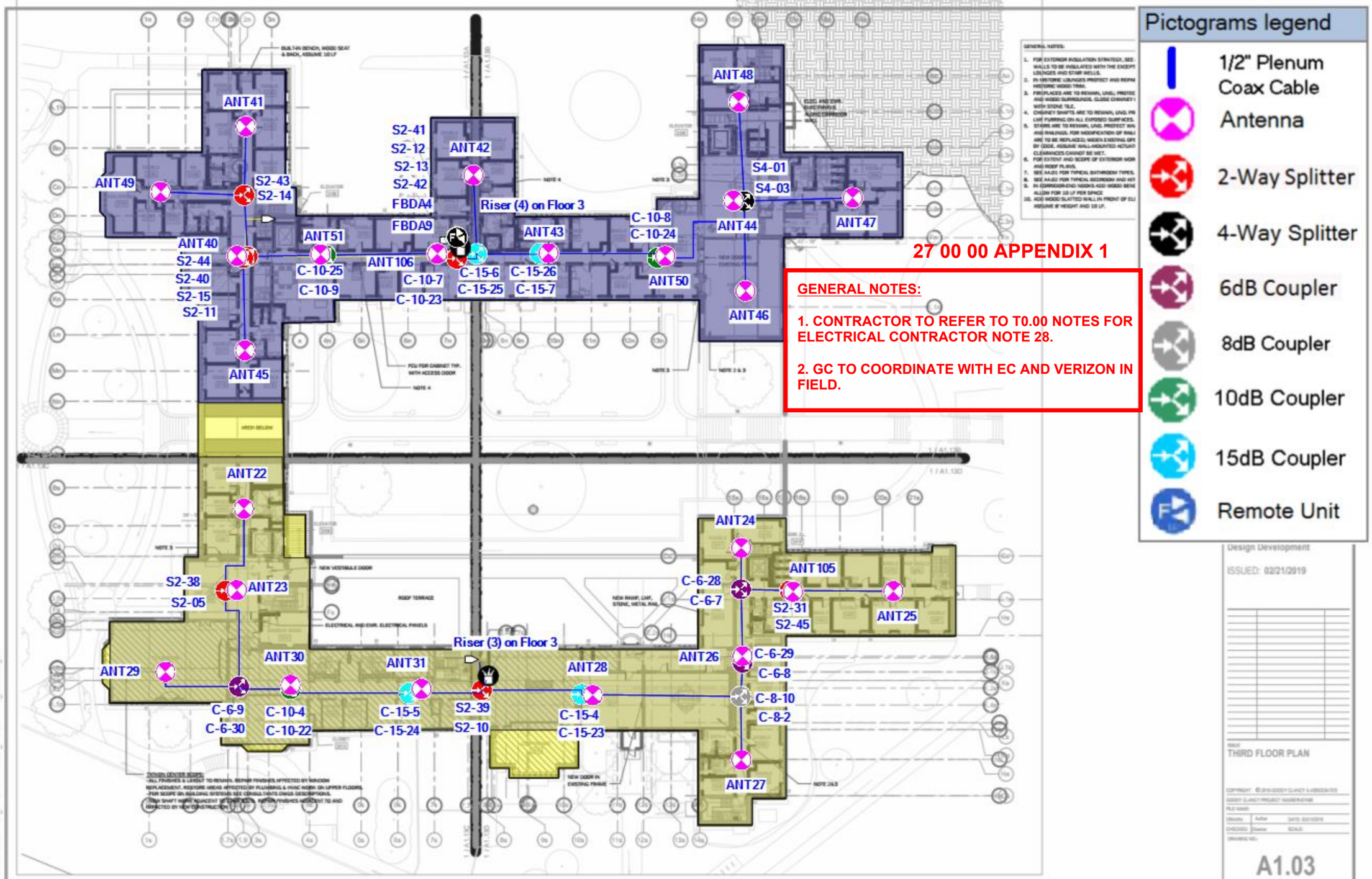
Greg Tobias

Plan name

Floor 2

Date

6/22/2020



27 00 00 APPENDIX 1

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Pictograms legend

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- 2-Way Splitter
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- 10dB Coupler
- 15dB Coupler
- Remote Unit

Design Development

ISSUED: 02/21/2019

THIRD FLOOR PLAN

A1.03

C Squared Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

Greg Tobias

Plan name

Floor 3

Date

6/22/2020

ANT53
ANT62
S2-48
S2-18
Riser (4) on Floor 4
Riser (2) on Floor 4
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C-10-11
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C-10-10
C-10-26
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ANT57
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ANT58
ANT77
S2-53
S2-23
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C-6-32
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ANT72
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ANT74
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C-15-11
S2-52
S2-22
FBDA6
FBDA10
C-15-12
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ANT70

27 00 00 APPENDIX 1

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- Remote Unit

Design Development

ISSUED: 02/21/2019

FOURTH FLOOR PLAN

A1.04

C Squared Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

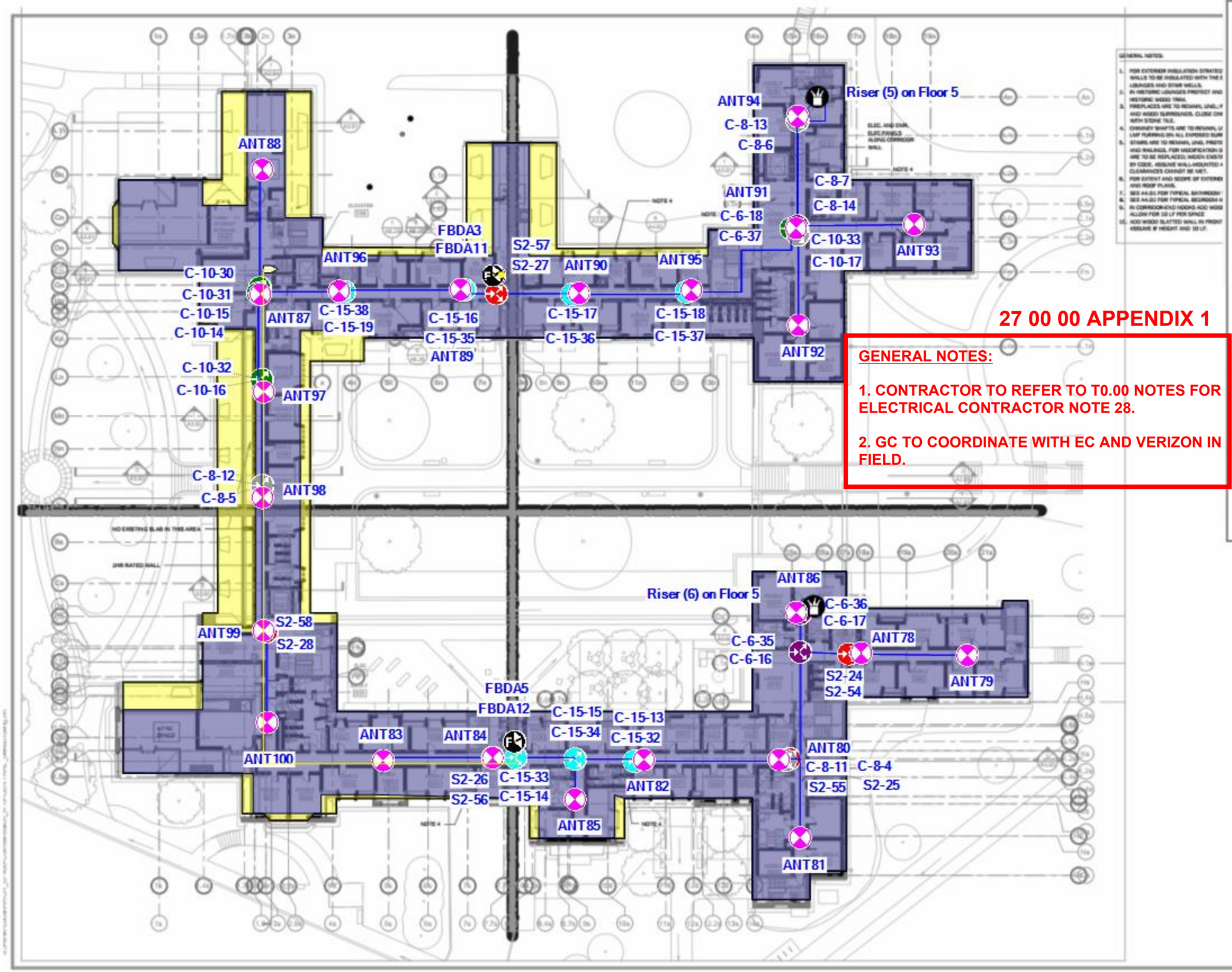
Greg Tobias

Plan name

Floor 4

Date

6/22/2020



27 00 00 APPENDIX 1

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- 10dB Coupler
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Design Development

ISSUED: 02/21/2019

FIFTH FLOOR PLAN

A1.05

C Squared Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

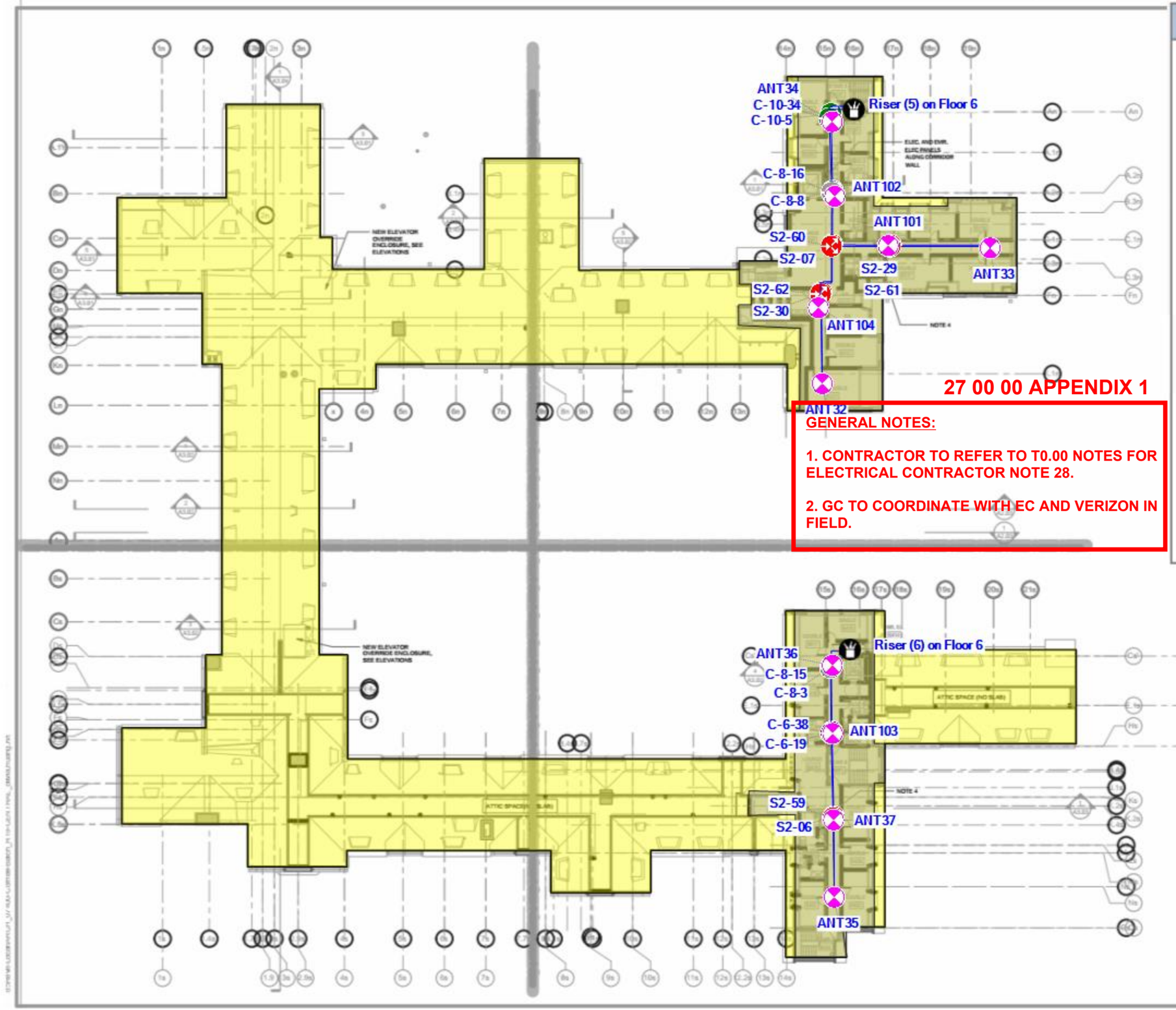
Greg Tobias

Plan name

Floor 5

Date

6/22/2020



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C² Systems
RF Engineering & Consulting

Indoor prediction legend

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

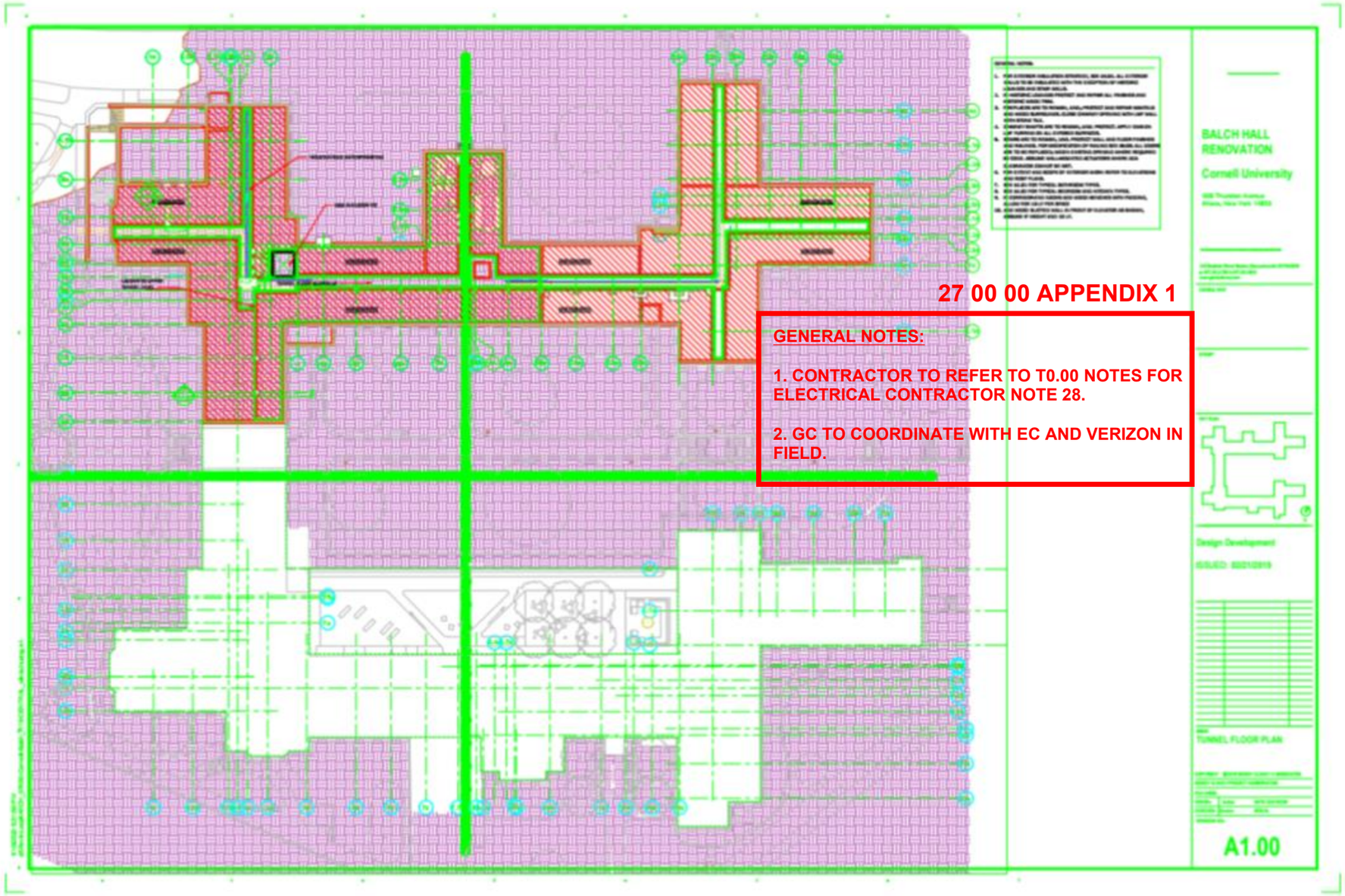
Greg Tobias

Plan name

Floor 6

Date

6/22/2020



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C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

Greg Tobias

Plan name

Tunnels

Date

6/22/2020

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C Squared Systems
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East Syracuse, NY 13057

Project name

Balch Hall

Designer name

Greg Tobias

Plan name

Design Notes

Date

6/22/2020

27 00 00 APPENDIX 1

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2. GC TO COORDINATE WITH EC AND VERIZON IN FIELD.

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Address	600 Thurston Ave, Ithaca NY	
State	New York	
County	Tompkins	
Latitude	N 42.452988	
Longitude	W 76.480260	
Venue AMSL	820 ft	
Site Contacts	Amanda Sanders	
Venue Special Access/Security	Contact Amanda Sanders	
700 MHz Spectrum	Upper C	
700 MHz Bandwidth	10 MHz	
1900 MHz Spectrum	C1	
1900 MHz Bandwidth	5 MHz	
1700/2100 MHz Spectrum	AB	
1700/2100 MHz Bandwidth	20 MHz	
Approximate Coverage Area	152,385 Square Feet	
Coordinate Source	Mapping Software	
System Type	Active, MIMO	
Fiber DAS Equipment (MFG and Model)	Teko - TRX7E8AE19HAWX23AT	
Main Head End Equipment Location	C.C.C First Floor Telephone Room 120	
Local Head End Equipment Location	First Floor MDF 1109	
Number of Remotes	12 (6 SISO, 6 MIMO)	
Fiber Remote Locations	FBDA1&7	Floor 2 Northside IT Closet
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	FBDA4&9	Floor 3 Northside IT Closet
	FBDA5&12	Floor 5 Southside IT Closet
	FBDA6&10	Floor 4 Southside IT Closet
Fiber Type	Lit Fiber	
Number of Interior Antennas	106	

C Squared Systems
6027 Corporate Drive
East Syracuse, NY 13057

Project name

Balch Hall

Designer name

Greg Tobias

Plan name

Overview table

Date

6/22/2020

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Section 27 41 00

AUDIOVISUAL SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. This section applies to the Audiovisual Systems scope only, but may be referenced by the General Contractor or their subcontractors for general information.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. The work of this Section consists of the provision of all materials, labor, and equipment and the like necessary and/or required for the complete execution of all audiovisual system installation and related work for this project as required by the schedules, keynotes and drawings, including, but not limited to the following:

1. Inspect the job site prior to start of AV system installation to identify any conflicts or issues that affect the installation of the AV systems. Notify the Architect and Consultant immediately of any items that require modifications to the system as designed.
    a. Conduit and Pathway Installation Inspection (must take place prior to installation or purchasing of product):
        1) Field verify the length of conduit runs to determine if distance limitations of signals have been exceeded. Notify the Architect and AV consultant immediately of any instances where conduit run distance may exceed distance limitations of signals. This may apply in particular to digital video signals being extended via transmission systems (twisted-pair type extenders, such as Crestron's Digital Media, Extron's DTP/XTP, AMX's DXLink, etc.).
        2) Field verify the exact path/routing of conduits to determine the pathways start and terminate at the locations required to support the functionality indicated within the AV documents (contract drawings and specifications).
        3) Notify the Architect and AV consultant immediately of any issues or discrepancies.
2. Unless otherwise specified, supply only new equipment, parts and material, and protect all equipment from construction dust and debris until final acceptance. Operate only as required for testing as part of installation procedure. Provision of all manufactured components, installation, wiring, and testing is the responsibility of a single contractor.
3. The audiovisual drawings indicate the general layout of the various items of equipment and their functional relationships. However, layout of equipment, accessories, and conduit systems are diagrammatic unless specifically detailed and do not necessarily indicate every item required for a complete installation. Provide any incidental equipment needed in order to result in a complete and operable system even if not specified or shown on drawings without claim for additional payment.

4. Quantities of all major installed and all portable equipment, including any add- or deduct- alternates, are indicated on the audiovisual drawings. Quantities of portable equipment are indicated in schedules contained in the drawings or specifications; quantities of installed equipment are determined by examining the functional diagrams, plans, and riser diagrams.
5. Refer to audiovisual drawings for receptacle back box location and quantity information. Also refer to architectural reflected ceiling plans for exact location of devices.
6. Verify correctness of parts lists and equipment model numbers and conformance of each component with manufacturer's specifications.
7. Obtain all permits necessary for the execution of the work. Comply with all applicable local codes and regulations.
8. All primary supports, conduit and wireways shown on the AV-series drawings are included in the General Contractor's scope of work and are not to be provided in the Audiovisual Contract. Supply and install all miscellaneous conduit and wireways to the extent not included in Division 26 in order to provide a complete and operable system.
9. Follow the on the existing audiovisual to the greatest extent possible, including selection of products and programming.

B. Functional Requirements of Systems:

1. General:
   a. All existing owner AV standards are to be adhered to the greatest extent possible.
   b. The audiovisual systems use similar technologies that have the corresponding operational features as described below. Users in each space will be presented a uniform interface that is intuitive and easy to use.
   c. The interface used to operate the audiovisual systems connects to the Ethernet network providing for 'helpdesk' and/or asset management functionality at each of the spaces required.
   d. Audiovisual systems for large spaces will communicate with the Fire Alarm System (FAS), the Lighting Control system, and the Shade Control system where applicable. The Lighting System and Shade System interfaces will allow the audiovisual system to recall respective system presets. The FAS connection will "mute" the audiovisual system and recall the appropriate lighting (and shade) preset.
2. Specific AV Systems:
   a. Entry Area
      1) Two flat panel displays will be located in the entrance area of the building, one located in each of the north and south Entry Lounge areas.
      2) They will be used for displaying digital signage content/branding, and will not be interactive or incorporate wayfinding. Content will be generated by the school, and may include information like daily events on campus, building metrics (power consumption, etc.), school sporting events, local weather, etc.
      3) Each display will include a signage player, mounted behind the display, which will be used with the schools current signage platform.

4) The monitors will be 55” class size and mounted in landscape orientation.

b. Typical Upper Floor Lounges
   1) Each space will include a straightforward presentation system that will be used for local collaboration between members within the room with local wired connections for students to connect portable devices.
   2) The system will include a wall mounted flat panel display with wall mount bracket and in-wall AV storage box.
   3) Attached to the sides of the display will be forward-firing accessory loudspeakers for playback of audio.
   4) In addition to the wired AV input, a wireless connection will be available using a Solstice Pod device, which will be mounted in the AV storage box behind the display.
   5) Below the display will be an AV connection panel, for extending HDMI and USB signals up to the display. The USB port will provide power for supporting the use of a portable Amazon Fire Stick or similar device.
   6) At the AV storage box will be an extra data port, to support future connection of an IPTV tuner.
   7) A wall mounted control panel will be located to the side of the display for turning the system on/off, selecting which source to display, and adjusting volume levels.

c. Break Out Room
   1) This space will be similar to the typical Upper Floor Lounge space described above, but will have an appropriately sized display to support the size of the room, it will not include the extra data port for the future IPTV tuner, and will include a USB web conferencing device.
      a) In this room, the USB from the web conferencing camera (Logitech Meetup) will be brought down to the AV connection panel, and instead of providing power for a Fire Stick or similar appliance, will allow users to connect personal devices (laptops) to facility bring-your-own-conference online meetings.

d. FIR Apartment
   1) This space will be similar to the typical Upper Floor Lounge space described above, but will have a bigger display to support the larger size room.

e. RHD Apartment
   1) This space will be used for watching television, and will only include a wall mounted flat panel display with wall mount bracket and in-wall AV storage box with an associated IPTV cable tuner.
   2) There will additionally be infrastructure provided at an alternate location for the display, to allow the option for it to be relocated in the future.

f. Unit Lounge 1 (Historic)
   1) This space will be based on the typical Upper Floor Lounge space described above, but scaled up accordingly for the larger room, and it will include additional features as described below.
      a) Dual display system – a large flat panel display will be located above the fireplace for watching television and basic presentations; with a video projector and motorized front projection screen for larger events requiring greater seating capacity.

b) Cable television – the spaces will include a school-supplied IPTV tuner.
c) Audio reinforcement capabilities – a wired microphone will be incorporated into the AV connection panel, and overhead distributed speakers will be provided for playback of audio that accompanies the video being displayed, as well as to provide speech reinforcement of the presenter.
d) Assistive listening system (ALS) – an IR based system that complies with current ADA standards will be provided for participants that are hard of hearing.
e) Touch panel controller – a wall mounted touchpanel control interface will be provided in this room to support the additional features/capabilities of the space.
f) Dedicated AV equipment rack – there will be a credenza located within the room that will include an AV equipment rack for housing the audiovisual components required to complete the system.

g. Typical Unit Lounges (Historic Lounges 2-4)
1) These spaces will be similar to the typical Upper Floor Lounges described above, but scaled up accordingly for the larger room as described below.
a) Larger flat panel displays display to support the larger size room.
b) These rooms will receive a school-supplied IPTV tuner for viewing cable television.
c) Attached to the sides of the display will be forward-firing loudspeakers for playback of audio.
2) Additionally, Unit 3 Lounge will have a custom monitor mount so it to be attached to the plaster wall above the wood but allow the display to be vertically offset, and mounted at the appropriate height above the floor.

h. Network based controls and remote management:
1) Provide building-wide support/management of the AV systems following Cornell's standards. They use an AV infrastructure service (formerly Manage AV) to provide subnetting, firewalls, remote monitoring and notifications, etc. They additionally use two more generic IT tools called Intermapper to create alerts in Opsgenie. These provide similar functions as a Crestron Fusion system does for notifying when an item is not functioning properly. The school additionally requires webproject touchpanel(s) to be loaded onto the processor by the programmer.

C. Related Work Specified Elsewhere:
1. Sustainability (01 81 13).
2. Metals (05 00 00).
3. Rough Carpentry (06 10 00).
4. Finish Carpentry (06 20 00).
5. Acoustical Ceilings (09 51 00)
6. Projection Screens (11 52 13)
7. Heating, Ventilating, and Air-Conditioning (23 00 00).
8. Electrical (26 00 00).
9. Communications (27 00 00).

10. Structured Cabling (27 10 00).

D. Definitions:

1. Owner: Cornell University.
2. Architect: Goody Clancy.
3. Consultant: Acentech Incorporated.
4. Bidder: Audiovisual contractor or other entity generating the response to this set of audiovisual bid documents.
5. Audiovisual Contractor or Contractor: Company that owner has awarded contract.
6. Furnish: Procure and deliver the equipment to the job site, freight prepaid, for receipt, staging and installation by others.
7. Installation: Provide, store, unpack and securely attach or mount equipment to structure following industry standards, approved shop drawings, and manufacturer recommendations.
8. Provide: Furnish and Install equipment.
9. Provided by Others and Not in Contract (NIC): Work related to this contract, but will be provided by parties other than the AV Contractor.
10. Owner Furnished Contractor Installed (OFCI): Equipment furnished by the Owner for installation by the Audiovisual contractor. The Audiovisual contractor shall be responsible for installing and integrating this equipment as detailed herein.
11. Installation Materials: Installed cable, loose cable, terminations, cable management, voice/data/video patch cords, adapters, I/O panels, cable dressing, lacing bars, copper bus bars, labels, rack shelves, rack mounts, power strips/distribution and other materials as needed to install the systems.

E. Equipment Furnished by Audiovisual Contractor and Installed by Others:

1. Provide the following device boxes/conduit boxes to the Electrical Contractor for installation (if not already provided by the Electrical or General Contractor):
    a. Display Monitor Boxes
    b. Ceiling Speaker Backboxes
    c. Control Panel Backboxes
    d. Others as indicated on AV Contract Drawings or required.
2. Provide inserts, cover plates, etc. as required for a complete system.

F. Equipment Furnished by Others and installed by Audiovisual Contractor:

1. Receive the following equipment/devices from the Owner and install them into the respective audiovisual systems and confirm system operation:
    a. Computers, wireless keyboards and mice.
    b. Cable television IPTV tuners with wireless handheld remote controls.
    c. Others indicated in the AV contract drawings.

1.4 CONTRACTOR QUALITY ASSURANCE

A. Project Management: Maintain the same person in charge of work throughout installation.

B. Contract Documents: Maintain a complete set of system drawings and specifications at the site at all times during installation.

C. Fabrication and Installation: Completely fabricate all equipment racks and subassemblies in contractor fabrication shop. Make field connections of all audio, video and control wiring including microphone, line level, loudspeaker, video, and control system circuits to equipment, equipment racks and connection panels. Continuously supervise the installation and connections of cable and equipment.

D. Contractor Qualifications: To be considered qualified for this work, the contracting firm must be experienced in the provision of audiovisual systems similar in complexity to those required for this project, and meet the following:

1. The Contractor's primary business is the provision, fabrication and installation of professional audiovisual and related systems.
2. The Contractor has been regularly engaged in the installation and service of professional audiovisual presentation systems for a period of at least five years.
3. The Contractor must be local to the project site (New York or Pennsylvania; nearby Connecticut, Rhode Island, or Massachusetts).
4. The Contractor is an authorized dealer for the major products furnished, including the specified Audiovisual Control System.
5. The Contractor is an experienced installer who is authorized representative of the equipment manufacturers for both installation and maintenance of equipment the required for this Section.
6. The contractor employs a certified programmer(s) for programming Audiovisual Control and Digital Audio Processor (DSP) systems.
7. The Contractor is, at a minimum, CAVSP Basic level certified solution provider, with at least (1) CTS-I and (1) CTS (or C-EST) certified employee on-site for the duration of the installation.
8. The contractor has an installer onsite at all times during the installation and termination of all equipment certified in the major products specified, including but not limited to:
    a. Biamp Certifications (as applicable)
    b. Crestron Certifications (as applicable)
    c. Others as required or necessary
9. At the request of the Architect demonstrate the following capabilities:
    a. Adequate plant and equipment to complete the work.
    b. Sufficient staff with appropriate technical experience to oversee and execute the work.

E. Subcontractors: The Contractor may arrange for sub-contract field and special shop work to be done by others.

1.5 SUBMITTAL REQUIREMENTS

A. General:

1. Contractor must provide four submissions as described in this specification. Those submissions include:

a. Bid submission.
b. Shop drawing, bill of materials, and programming.
c. Test reports.
d. As-Built drawings and operation manuals.

2. In keeping with the practices of LEED™, all submittals shall be delivered in electronic format as Excel *.xlsx, AutoCad *.dwg, Revit *.rvt, Word *.docx, or combined PDF files via FTP posting, DVD, USB-flash drive or e-mail.
3. Contents and Delivery Schedule:
   a. Bid submittal package: By date specified.
      1) Basis of bid documents, including:
         a) Itemized equipment costs for specified equipment or APPROVED substitutions.
         b) Qualifications/References.
         c) Certifications (including certificate of bonding, if required).
         d) Proposed payment terms.
   b. Shop drawing and bill of material submission: No later than 60 days following award of contract provide the following as one unified package:
      1) Shop drawings.
      2) Bill of materials.
      3) Manufacturer product data sheets.
      4) Control system layouts and digital signal processing configurations.
   c. Test result submission: No later than one week before acceptance testing provide the following:
      1) System test and certification reports.
      2) Manufacturers' equipment owner's manuals.
      3) One (1) draft copy of user operational manuals.
      4) One (1) draft copy of "as-built" system diagrams.
   d. As-built drawings and operational manual submission: Within 30 days after final acceptance testing visit provide the following:
      1) Final as-built system diagrams in hard copy and editable electronic file formats.
      2) Final user operational manuals in hard copy and editable electronic file formats.
      3) Control software for AV Control System, digital signal processors, and other programmable devices. Include complete job-specific source code files.
      4) Custom finish material samples, if applicable.
4. Unless otherwise directed by Contract, do not order equipment until the bill of materials has been reviewed and approved by the audiovisual consultant.
5. Approval for isolated items will not be considered, except by prior approval by the audiovisual consultant.
6. Rejected items and items requiring correction must be resubmitted at one time, unless authorized otherwise.

1.6 BID SUBMITTALS

A. Instructions to Bidders: To be considered, Bids must be made in accord with the Architect's Instructions to Bidders and this Article.

B. Examinations: Carefully examine the contract documents and the construction site to obtain first-hand knowledge of existing conditions. Contractors will not be given extra payments for conditions that can be determined by examining the site, and will not be relieved of any obligations with respect to bid.

C. Questions: Submit all questions about the contract documents in writing. Replies requiring changes to the contract documents will be issued to all bidders as addenda and will become part of the Contract. The Architect and Owner may give but will not be responsible for oral clarifications. Questions received less than 10 days before bid date cannot be answered in writing.

D. Acceptable Products: Model numbers and manufacturers identified herein indicate a standard of quality and performance. Other products will be considered subject to approval of complete technical data, samples and results of independent testing of proposed equipment, submitted in accordance with Division 1 requirements and “Substitutions” section below.

E. Substitutions: To obtain approval for substitutions and for items identified as "approved equal", submit written requests at least 10 days before bid date. Requests received after this time will not be considered. Requests shall clearly describe the product for which approval is asked, including all data necessary to demonstrate acceptability. If the product is acceptable, an Addendum may be issued to all bidders.

F. Equipment Availability: Verify with manufacturers availability and cost of all equipment proposed, including equipment specified herein. No cost increases will be allowed for manufacturers' cost increases, or for substitutions required because of unavailability of proposed equipment.

G. Performance Bond: The successful bidder will furnish a Performance Payment Bond and Labor and Material Bond, underwritten by a surety company approved by the Architect and Owner, for fulfillment of all provisions of the contract.

H. Basis of Bids:

1. Submissions will be provided in electronic format described below. Electronic submissions must be supplied in PDF and Microsoft Excel *.xlsx format.
2. Include a complete itemized list for each base-bid system indicating the manufacturer, model number, unit cost and total costs for all specified items. Itemization of miscellaneous equipment such as cable, switches, and receptacles is not required.
3. Organize each list with the information presented, in the order that it appears in this specification, in 6 columns from left to right:
    a. Paragraph number as it appears in this specification.
    b. Paragraph title as it appears in this specification.
    c. Manufacturer and model number.
    d. Quantity.
    e. Unit Cost.
    f. Extension (unit cost times quantity).

Example:

Paragraph #	Paragraph Title	Manufacturer & Model Number	Qty.	Unit Cost	Extended Cost
Section 2.1	**Microphones**				
2.1.B	Hand-Held Microphone	xxx	#	$$	$$$$

4. At the end of each list indicate the cost of all other “overhead” items such as for miscellaneous equipment, engineering, installation labor, taxes, etc. with a separate sub-total.
5. On a separate list indicate costs of any specified add- or deduct-alternates with the information presented in the same manner as for the base-bid system.
6. Include a listing of any voluntary alternates proposed by the bidder as substitutions or additions to the specified systems.
7. Include any notes or comments if necessary to qualify the bid.
8. Identify any sub-contractors and indicate the work they are to do.
9. Clearly indicate the total cost, with all systems as own line items, including all overhead expenses, listing each individual system to allow the Owner to select any or all to be included in the contract.

I. Bid Qualifications:

1. Provide documentation of ability in installing similar systems. Furnish the names, addresses and telephone numbers of the System Designer, Architect, General Contractor and Owner on three projects similar in scope, which the Contractor has installed within the last 5 years.
2. Include certification of ownership and full familiarity with the operation of the following minimum test equipment or current equivalents. Provide a list of the manufacturer, model, and serial number for each item of test equipment required.
    a. Audio Test Equipment:
        1) SMAART, EASERA or similar measurement platform that includes a laptop computer, audio preamp, Type 1 measurement microphone and all necessary cables stands, etc. to complete the system.
        2) AC impedance bridge.
        3) Sound level meter and octave band filter set.
        4) Digital Multimeter.
        5) Calibrator with appropriate microphone adapter similar to General Radio, Norsonic, or Rion calibrators.
        6) Random or pseudo-random pink noise generator.
        7) Cable Tester (suggested: Whirlwind DCT-9 or PylePro PCT40).
        8) Loudspeaker polarity indicator (suggested: BSS Audio AR130,).
    b. Video Test Equipment:
        1) Photometer with luminance and illuminance probes.
        2) TriStimulus Color Analyzer with Laptop computer (suggested: Sencor OTC1000-CM).

3) Multi-frequency computer RGB test pattern generator (suggested: Extron VTG-300R, VTG-400D or VTG-400DVI).
4) HDMI test pattern generator (suggested: TV One 1T-TG-620 HDMI Pattern Generator or Sencore MP500
5) HDMI cable test instrument similar to the Quantum Data 780.
6) Coaxial cable test kit (for testing whether in-place cable will support SDI signals): FM Systems CTG-500 kit.

c. RF Test Equipment:
1) Signal Level Meter (Trilithic Model Three or equal).
2) Leakage Detector (Trilithic Seeker Lite2 or equal).

d. Fiber Optic Test Equipment:
1) Optical Loss Test Set (Trilithic TFS-401 or equal).
2) OTDR (Trilithic TFS-2500 or equal).
3) Corning OTS-600 Series Optical Test Set (OTS-6MDSD or equal).

e. LAN Test Equipment:
1) CAT Cable Tester (Fluke DTX-1800 CableAnalyzer or equal).
2) WiFi Tester (Fluke AirCheck or equal).
3) WiFi Analyzer (Fluke AirMagnet or equal).

1.7 SUBSTITUTIONS

A. General: The Contractor has the burden of proving, at the Contractor's own cost and expense and to the satisfaction of the Architect and AV Consultant, that the proposed product is similar and equal to the named product.

B. Basis:
1. Requests for acceptance of proposed equivalents made following the award of bid will be considered only in the following cases:
a. The named products cannot be obtained by the Contractor because of strikes, lockouts, bankruptcies or discontinuance of manufacturer and the Contractor makes a written request to the Architect for consideration of the proposed equivalent.
b. The proposed equivalent, in the opinion of the Architect and AV Consultant, is equal or superior to the named product and its use is to the advantage of the Owner.
2. A formal request must be made for the substitution documenting fully the above reason. Include complete data on the proposed substitution substantiating compliance with the Contract Documents including product identification and description, performance and test data, references and samples where applicable, and an itemized comparison of the proposed substitution with the products specified or named by Addenda, with data relating to Contract time schedule, design and artistic effect where applicable, and its relationship to separate contracts. Accompany the request by accurate installed cost data on the proposed substitution in comparison with the product specified.

C. Consideration:
1. A request for substitution is a representation by the Contractor that:

a. The Contractor has personally investigated the proposed substitution and determined that it is equal or superior in all respects to that specified.

b. The Contractor will provide the same warranty for the substitution that would be for that specified.

c. The cost data presented are complete and include all related costs under this Contract, but exclude costs under separate contracts and exclude Architect's re-design costs, and that the Contractor waives all claims for additional costs related to the substitution which subsequently become apparent.

d. Indicate if there will be any cost impact on work by other trades.

e. The Contractor will coordinate the installation of the accepted substitute, making such changes as may be required for the Work to be complete in all respects.

2. An accepted substitution will be documented by Change Order modifying the Specifications. The Contract Price will be changed only if the substitution results in cost savings to the Owner.

1.8 SHOP DRAWING AND BILL OF MATERIAL SUBMITTALS

A. Coordinate all submittals with requirements set forth in Section 00 10 00 Solicitation.

B. Drawings will be in current AutoCad *.dwg format and portable document format (PDF). All other submissions unless otherwise stated will be provide as PDFs.

C. Shop Drawings and Bill of Materials Submittals:

1. General:

a. The following is required for approval, prior to ordering product, fabrication and installation. Submit complete and at one time. Isolated items will not be considered for approval, except by prior authorization. Rejected items and items requiring correction must be resubmitted at one time, except by prior authorization.

b. Submittals shall be provided as complete electronic PDF files and (1) hard copy set that include the following items or information:

1) A single collated file of the Bill of Materials for each system, listed in the order it appears in this specification, configured to print on standard 8-1/2” x 11” or 11” x 17” paper.

2) A single collated file of all cut sheets for equipment listed in this specification configured to print on standard 8-1/2” x 11” paper.

3) A single collated file containing drawings configured to print as a full-size set at project standard sheet size.

4) Control system touchpanel layouts, as identified below.

5) Digital signal processing layouts, as identified below.

6) Product finish information, indicated on product data sheets and shop drawings.

c. The diagrams and details included with these specifications, modified to reflect the stated requirements and to reflect the details of the system as awarded, and including all additional required information, may be used in preparing shop drawings. Drawings that are submitted without the necessary modifications will be rejected.

1) Showing “Typicals” is not acceptable. Each system or item must be drawn out and/or detailed in its entirety.

2. Bill of Materials and Catalog Data Sheets:
   a. Electronic submissions must be supplied in PDF and Microsoft Excel *.xlsx format.
   b. Provide a Bill of Materials and Catalog Data Sheets of all manufactured items. At the end of the Bill of Materials include Catalog Data Sheets (“cut” sheets) for all product arranged in the order listed in the specifications and in the Bill of Materials. Include a cover page identifying the project and submittal. Organize the Bill of Materials with the information presented in the order that it appears in this specification, in 6 columns from left to right:
      1) Paragraph number as it appears in this specification.
      2) Paragraph title as it appears in this specification.
      3) Manufacturer.
      4) Model number.
      5) Quantity.
      6) Comments (if any are needed).

   Example:

Paragraph #	Paragraph Title	Manufacturer	Model Number	Qty.	Comments
Section 2.1	**Microphones**				
2.1.B	Hand-Held Microphone	xxx	xxx	#	

3. Shop Drawings:
   a. Plan & RCP Drawings: Provide plan and reflected ceiling drawings indicating all device locations and pathways of cable routing given conduit system as installed, complete with drawing list and all required symbol legends and keys.
   b. Block diagrams: Provide block diagrams of proposed connections of all equipment.
      1) Show all cable numbers/designators.
      2) Provide a key indicating cable type/manufacturer for each signal type used.
      3) Label all devices with manufacturer make and model information.
   c. Detail and Mounting Drawings:
      1) Room Layouts: Provide drawings detailing equipment/projection/control room layout(s), and equipment rack and cabinet installation details.
      2) Video Projectors: Provide plan and section drawings verifying image width, lens-to-screen distances and mounting methods. Provide detailed drawings of custom-fabricated or stock mounts and hardware, as well as locations of auxiliary electronic devices, such as digital media receivers.
      3) Projection Screens: Provide elevation drawing for each projection screen showing floor, ceiling, and screen, with screen size and dimensions for extra drop and image height above the floor indicated.
      4) Flat Panel Displays: Provide drawings showing displays, display mounts, method of attaching mounts to structure, and locations of auxiliary electronic devices, such as digital media receivers.

5) Cameras, Antenna, Monitors, and Control Panels: Provide drawings in plan, elevation and section the detail mount arrangements and orientation for video camera, video monitors, antenna and control panels.
6) Loudspeaker arrays or clusters: Provide drawings showing arrangement of all arrayed loudspeaker components, showing physical arrangement and orientation as well as structural support and any nearby architectural components affecting the coverage provided by the arrayed loudspeakers. Provide drawings stamped by a certified structural engineer indicating review and approval of indicated structural supports.
7) Rack, Plate, and Panel Details: Provide equipment detail drawings, including rack elevations and custom plate details, complete with all finish information and text height/font information.
8) Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location of each field connection.
9) Shop drawings of any unit, such as control panels, switch panels, or loudspeaker enclosures or grilles, to be fabricated or modified.

d. Others as required by Architect or Consultant.
e. As part of the submittal, identify which finishes are available for products with color options, and submit AV equipment finishes to the Architect and Consultant for review and approval.

4. Audiovisual Control System:
   a. Provide detailed control panel layouts and control logic notes, prepared by the control system programmer to the AV Consultant for review and approval.
      1) Include tree diagrams indicating signal flow for review and approval by Owner and AV consultant.
   b. Upon approval of the above by AV Consultant, and prior to beginning control system code development, provide color draft set of control system touchpanel layout diagrams for review and approval by Owner and AV consultant, noting all comments from prior review
      1) Page graphic information will include text, buttons, colors, images, and backgrounds as well as page flips, sub-pages and overall page logic flow.
   c. Upon approval of the above by AV Consultant, provide control system touchpanel programming file for final review and approval by Owner and AV consultant, noting all comments from prior review.
   d. Incorporate all Owner standards where applicable. Standards include, but are not limited to:
      1) Existing page graphic standards
      2) Graphics, colors, watermarks, or fonts
      3) Others as requested by Owner
5. Digital Signal Processing:
   a. Provide detailed signal flow and control logic diagrams to the AV Consultant for review and approval, including but limited to:
      1) Signal flow diagrams.
      2) Detail presets and interconnection to audiovisual control system.

D. Samples:

1. Finish for control panels, racks, cabinets, and loudspeaker grilles.
2. Mechanical connectors for use in wiring.

1.9 TEST REPORT SUBMITTALS

A. Test Reports: Upon completion of SYSTEM PERFORMANCE TESTS AND ADJUSTMENTS specified in PART 3 - EXECUTION, submit for approval in writing test results including numerical values for all measurements. Also submit written certification that the installation conforms to specifications, is complete and operable, and is ready for FINAL ADJUSTMENTS AND ACCEPTANCE TESTS specified in PART 3 - EXECUTION. Provide three (3) copies unless otherwise specified.

1.10 AS-BUILT DRAWINGS AND OPERATION MANUAL SUBMITTALS

A. General:

1. The following is required for approval, prior to final AV system commissioning. Submittals made not meeting the criteria outline below will be rejected.

B. Operation and Maintenance Data:

1. Draft Copies: At time of FINAL ADJUSTMENTS AND ACCEPTANCE TESTS specified in PART 3 - EXECUTION, provide draft copies of all specified diagrams, schedules and manuals for inspection during demonstration and acceptance testing. Submit final copies of documents within 30 days of project acceptance date. All drawings shall be drawn using current AutoCad version. For Contractor prepared drawings, schedules and instructions, provide (1) draft copy and (2) final copies in electronic format for inclusion in the specified Complete Instruction and Maintenance Manual.
2. Drawings: All drawings will be in the project document size (example E-size).
3. Functional Diagrams: Simplified single line block diagram showing interconnection of all major equipment components and functional relationships. Illustrate all receptacles, patch panel jacks, attenuators, transformers, switches, and loudspeakers. Key each patch panel jack to the patch bay by row and jack number. Diagram shall not illustrate terminal or interconnection cable number designations The Functional Diagram included with these specifications, modified to exclude details, transformer tap designations, etc., and to provide the information described above and any as-built changes, is suitable for this purpose.
4. As-Built Diagrams:
    a. The intent of the diagrams is to provide sufficiently clear and complete information that a technician of average skill may efficiently troubleshoot and service the system, even if unfamiliar with the installation.
    b. Provide drawings showing all terminal blocks, connectors, relays, switches, transformers, attenuators, equipment components, and wires. Label all devices with manufacturer, model number, and reference number (e.g. "SW 15", "TB 6"); reference numbers shall be consistent across all drawings with no repetitions. As a minimum, provide an expanded version of the functional diagrams with cables fanned out at termination points and all labeling as specified above; provide additional drawings where system complexity does not permit complete information to be shown legibly on an individual sheet no larger than the project sheet size. Provide labels for cables continued onto another drawing, indicating

termination device, terminal numbers, and drawing sheet on which the termination is shown.

c. As-built drawings are to include full connection information for each termination of conductors within a cable, either on the drawing itself via cable breakouts or by designating the connection type and providing

d. Provide layout drawings of panels and other custom assemblies containing switches, relays, terminal blocks, receptacles, etc., using reference numbers to identify physical locations of devices or label devices with reference numbers in a location visible while viewing cable terminations. On wiring diagrams, label all conductors within cables for insulation color or other identifier. Label connectors, barrier strips, switches, relay sockets, etc., for terminal number. If device does not provide terminal designations, provide key diagram for reference.

e. Receptacle Location Plan: Plan of area showing locations and designations of all receptacles.

f. Control Setting Schedule: Fully document the settings of all non-user-adjustable controls. This includes power amplifier gain controls, equalizer settings, etc.

g. Patch Panel Assignment Schedule: Mount a typed schedule of patch panel assignments behind acrylic at the equipment racks.

h. Spare Parts List: List of consumable spare parts (projector lamps, air filters, etc.) with part numbers.

C. Complete Instruction and Maintenance Manual: Prepare in the form of an instructional manual for use by Owner's personnel. Provide one (1) draft copy and two (2) final copies unless otherwise specified.

1. Format:

a. Size: 8-1/2" x 11", 20 lb. minimum weight white paper for typed pages, either manufacturer's printed data, or neatly typewritten.

1) Cover: Identify each volume with typed or printed title "OPERATING AND MAINTENANCE INSTRUCTIONS".

2) Single-sheet product literature and contractor-prepared pages: Provide reinforced punched binder tab. Clear plastic "binding tape" (not "Scotch" tape) applied to edge of page and then punched is acceptable.

3) Provide indexed tabs and flyleaf for each separate product, or each piece of operating equipment. Include typed description of product, and major component parts of equipment.

4) Original Owner and Maintenance Manuals provided from manufacturer or high-quality color reproductions.

b. Drawings: Provide sequenced bound drawings in project standard size.

2. Binders:

a. Commercial quality three-ring binders with durable and cleanable plastic covers, 1" minimum, 2" maximum ring size.

b. When multiple binders are used, collate the data into related consistent groupings.

3. Content of Manuals:

a. Provide a table of contents arranged in systematic order. Identify each product by product name and other identifying symbols as set forth in Contract Documents.
b. Contractor, name of responsible principal, address and telephone number.
c. Certificate of Warranty for the system as a whole as well as copies of the manufacturer's warranty for each equipment item.
d. Service Contract. Include a preliminary schedule for the specified semi-annual site visits.
e. Complete as-built diagram(s) for systems.
f. Functional Diagram(s).
g. Receptacle Location Plan.
h. Patch Panel Assignment Schedule.
i. Building Plan.
j. Original copies, high-quality laser printer printouts of PDF files, or high-quality photocopies of manufacturers' installation, operation, and service manuals, including schematic diagrams for each equipment item.
k. Shop drawings of all custom-fabricated items.
l. Control Setting Schedule.
m. Audiovisual Control System:
    1) Color printouts of touch screens control panel graphic layouts, as installed.
    2) Listing of system brand, models and all associated peripherals.
    3) DVD or USB flash drive containing the master program for the system, the touch screen display program (including all macros), all programming, communication, or other project-specific software required for re-programming, and a limited license agreement for the use and modification of contractor-generated source code in connection with the maintenance and modification of the system for which it was written.
n. Software for Programmable Devices: Where a computer has been used in programming system components, provide or USB-flash drive containing the software, instructions for making interconnections to the programmed devices for the purpose of modifying the programming, and a limited license agreement for the use and modification of contractor-generated source code in connection with the maintenance and modification of the system for which it was written.
o. All applicable software and hardware licenses to be documented and original copies of the licensed provided to owner.

D. Upon request, electronic copies of bid drawings can be made available in PDF format. Requests must include the project name, project number, drawing numbers and type of files requested. Requests should be forwarded to:

Corey Salvatore
Acentech Incorporated
33 Moulton Street
Cambridge, MA 02138
Tel: 617-499-8000, Fax: (617) 499-8074
Reference Job Number: 630575

1.11 JOB CONDITIONS

A. Sequencing and Scheduling:

1. Coordinate work with adjacent work of other trades to facilitate construction and prevent conflicts.
2. Afford other trades reasonable opportunity for installation of work and for the storage of materials.
3. Staff the job to keep pace with the other Trades; otherwise, the Architect will require an increase in force or overtime work without additional expenses to the Owner.
4. Abide by the decision of the Architect in case of conflict or interference by other trades.
5. Refuse: Remove all refuse from the job site to the satisfaction of the Architect and Owner.

B. Insurances on the work of this specialty trade shall be provided as specified in Section 00810.

1.12 WARRANTY

A. Warrant all equipment to be free of faulty workmanship and defects, and from damage due to contamination by construction dust and debris for a minimum period of one year from date of final acceptance.

B. Warrant all repairs to "existing" equipment for a period of 90 days.

C. Emergency service: Within 24 hours of notification, restore the system to operation, replacing defective materials and repairing faulty workmanship. Make temporary repairs and provide loaner equipment at no charge if defective materials cannot be permanently replaced or repaired within this 24 hour time period.

D. Paint and exterior finishes, fuses, lamps, projection lamps, and video picture tubes excluded from above warranties except when damage or failure results from defective materials or workmanship covered by warranty.

E. The minimum warranty provisions specified above shall not diminish the terms of individual equipment manufacturers' warranties.

1.13 SERVICE CONTRACT

A. Provide a one-year service contract to commence after acceptance of installation without additional cost. Service to include two semi-annual visits to the site for routine adjustment and maintenance of all equipment. Provide a preliminary schedule for the semiannual visits.

B. Towards the end of each year's Service Contract, provide the owner with a proposal for continued service during the next year.

1.14 TRAINING

A. The Owner may assign personnel to participate with the contractor during installation. Without delaying the work, familiarize the Owner's personnel with the installation, equipment, and maintenance.

B. During tests and adjustments, permit the Owner's personnel to observe. When feasible explain the significance of each test.

C. Provide sufficient training to personnel selected by the Owner on operation and basic maintenance of all systems and equipment. Explain operation of control systems, set-up and operation of individual pieces of equipment and functions of overall systems.

D. Separate from the bid response quotation; provide an hourly cost for additional training.

1.15 INSPECTION

A. Notify the Architect of any defects in work by other trades affecting installation.

PART 2 - PRODUCTS

2.1 GENERAL

A. All items are to be provided with all included software and accessories, as well as any additional accessories, software, power supplies, modules, or hardware as required for a complete system.

B. Items listed in the specification provide the make and model of equipment to be provided. In some instances, due to the phasing of the project, Others (such as the Owner or the General Contractor) may provide certain pieces of the equipment. The items supplied by others may include recessed ceiling speakers, back boxes for control system panels, flat-panel display back box, projector ceiling boxes, and floor boxes. Where this occurs, verify manufacturer and model of installed back box and provide appropriate corresponding product.

C. Wherever possible, follow existing owner standards for manufacturers, audio DSP programming, and control system programming.

D. All mounted devices that are exposed, such as loudspeakers, video projectors, etc. as well as the associated mounting and cabling are to be provided with finish approved by the Architect and AV Consultant.

E. All products selected will conform to Owner standards for AV systems. Known related standards include:

1. An owner-furnished Intel NUC computer running Appspace software (via Central Services) is the campus standard for digital signage players and content system platform.
2. Da-Lite (16:10 aspect ratio) is the campus standard for projection screens.
3. PoE power will be available from Cornell's network edge switches.

2.2 AUDIO SOURCES

A. Handheld Microphone:

1. Hand-held wired vocal microphone designed for professional use in live events with cardioid dynamic microphone element and rugged construction for handling and durability.
2. Acceptable Products:
   a. Shure SM58-CN.
   b. Approved equal.

2.3 AUDIO PROCESSING

A. Audio Combiner:

1. Passive combiner for summing unbalanced stereo inputs to balanced mono outputs.
2. Acceptable Products:
   a. RDL STD-10K with mounting hardware as required to secure device.
   b. Approved equal.

2.4 AUDIO AMPLIFICATION

A. Type 1 Stereo Amplifier:
   1. Solid-state, two-channel power amplifier with 8 ohms operation mode providing minimum of 40W power per channel.
   2. Acceptable Products:
      a. Pyle Pro PCA2 Mini with mounting hardware as required to secure device.
      b. Approved equal.

2.5 LOUDSPEAKERS

A. Type 1 Ceiling Loudspeaker:
   1. Two-way ceiling loudspeaker assembly in blind-mount back can for installation in accessible ceilings including a coaxially mounted 6.5” woofer, 3/4” dome tweeter, and minimum 60W multi-tap transformer for 70V operation, with minimum 88 dB sensitivity and 110° conical coverage pattern.
   2. Acceptable Products:
      a. QSC AC-C6T with accessories and mounting hardware as required.
      b. Approved equal.

B. Flat Panel Loudspeaker:
   1. Forward-firing side-mounted loudspeakers that attach to the display, custom size to match display height.
   2. Acceptable Products:
      a. Innovox FS-V2 series speakers with mounting hardware as required. Provide with “oversize” option as necessary for larger displays.
      b. Approved equal.

2.6 ASSISTIVE LISTENING SYSTEM

A. IR-based ALS System:
   1. General:
      a. ADA compliant RF-based listening assistance system for wireless transmission of audio to portable hand-held receivers.
      b. Coordinate location of emitter with Owner, Architect, Electrical Contractor and AV Consultant.
   2. IR Combo Modulator Emitter:
      a. IR radiator with integrated modulator in compact, low-profile body for mounting on a wall or to a ceiling.
      b. Acceptable Products:
         1) Listen Technologies LT-84 with included accessories. Supply with mounting hardware as required and in finish approved by Architect.
         2) Approved equal.
   3. Receiver with Ear Speaker (and Neck Loop):

a. Portable handheld IR receiver with single ear speaker and lanyard with integral neck loop.
b. Acceptable Products:
1) Listen Technologies LR-4200-IR-P1 receiver package with neck loop and ear speaker.
2) Approved equal.

4. Charging Station:
a. Master charging unit for recharging multiple receiver units.
b. Acceptable Products:
1) Listen Technologies LA-380 with power supply.
2) Approved equal.

5. ADA Signage:
a. Assistive listening notification signage kit. Coordinate location of placards with Architect and Owner.
b. Acceptable Products:
1) Provide with (1) LA-303 for each room with an installed ALS system.
2) Approved equal.

2.7 VIDEO SOURCES

A. Wireless Collaboration Device:
1. Wireless collaboration appliance that allows Wi-Fi connection of laptops and mobile devices to video displays for presentation.
2. Acceptable Products:
a. Mersive Solstice Pod Gen 3 SGE Enterprise edition with 5-year support subscription (SP-8100-E5) with mounting hardware as required to secure device.
b. Approved equal.

B. USB Web Camera:
1. Video camera for web conferencing using soft-client codecs on computers, with 120° field of view 4K image sensor, integrated triple-element beam-forming microphone system, and motorized pan/tilt capabilities.
2. Acceptable Products:
a. Logitech MeetUp camera with TV mounting bracket and hardware as required.
b. Approved equal.

2.8 VIDEO PROCESSING

A. Type 1 Video Switcher:
1. All-in-one 8x2 matrix switcher for 4K video with internal scaler, audio DSP with AEC, audio amplifier, control processor, and integrated HDBaseT extension outputs.
2. Acceptable Products:
a. Crestron DMPS3-4K-350-C with rack ears and mounting hardware as required. Supply with Crestron PW-5430DUS PoDM/PoE power supply.
b. Approved equal.

B. Type 1 Video Transmitter:
   1. Remote input connection wall plate for HDMI sources that transmits 4K audiovisual signals via HDBaseT using a single category cable.
   2. Acceptable Products:
      a. Crestron HD-TX-101-C-1G-E-#-T transmitter plate (as part of HD-MD-4K-200-1G kit) with mounting hardware as required in finish approved by the Architect.
      b. Approved equal.

C. Type 2 Video Transmitter:
   1. Remote input connection wall plate for HDMI sources that transmits 4K audiovisual signals via HDBaseT using a single category cable.
   2. Acceptable Products:
      a. Crestron DM-TX-4KZ-100-C-1G-#-T with mounting hardware as required in finish approved by the Architect.
      b. Approved equal.

D. Type 1 Video Receiver:
   1. Remote receiver that allows 4K audiovisual signals to be sent long distances via HDBaseT using a single category cable with internal scaler and auto switching between extended input and local HDMI input.
   2. Acceptable Products:
      a. Crestron DMPS Lite 210 (HD-RX-4K-210-C-E) receiver (as part of HD-MD-4K-200-1G kit) with mounting hardware to secure device and accessories as required.

E. Type 2 Video Receiver:
   1. Remote receiver that allows 4K audiovisual signals to be sent long distances via HDBaseT using a single category cable with internal scaler.
   2. Acceptable Products:
      a. Crestron DM-RMC-4KZ-SCALER-C with mounting hardware to secure device and accessories as required.
      b. Approved equal.

F. HDMI Equalizer:
   1. Emulation device for 4K EDID communication with the source based on pre-selected resolution and refresh rates, with automatic input cable equalization that conditions incoming HDMI signals to compensate for signal loss when using long cables, low quality cables, or source devices with poor signal output.
   2. Acceptable Products:
      a. Extron EDID-101H-4K with mount kit and mounting hardware as required to secure device.
      b. Approved equal.

2.9 VIDEO DISPLAYS

A. 55” Flat Panel Display:

1. A commercial grade 55-inch ultra-high definition (UHD) display designed for 24/7 operation with minimum 500 cd/m2 (at standard/typical mode operation), anti-glare surface, and bi-direction 3rd party control capabilities (RS-232 or IP based) with accessory forward-firing side-mounted loudspeakers.
2. Acceptable Products:
    a. Samsung QM55N with specified wall mount and mounting hardware as required.
    b. Approved equal.

B. 65” Flat Panel Display:
1. A commercial grade 65-inch ultra-high definition (UHD) display designed for 24/7 operation with minimum 500 cd/m2 (at standard/typical mode operation), anti-glare surface, and bi-direction 3rd party control capabilities (RS-232 or IP based) with accessory forward-firing side-mounted loudspeakers.
2. Acceptable Products:
    a. Samsung QM65N with specified wall mount and mounting hardware as required.
    b. Approved equal.

C. 75” Flat Panel Display:
1. A commercial grade 75-inch ultra-high definition (UHD) display designed for 24/7 operation with minimum 500 cd/m2 (at standard/typical mode operation), anti-glare surface, and bi-direction 3rd party control capabilities (RS-232 or IP based) with accessory forward-firing side-mounted loudspeakers.
2. Acceptable Products:
    a. Samsung QM75N with specified wall mount and mounting hardware as required.
    b. Approved equal.

D. 85” Flat Panel Display:
1. A commercial grade 85-inch ultra-high definition (UHD) display designed for 24/7 operation with minimum 500 cd/m2 (at standard/typical mode operation), anti-glare surface, and bi-direction 3rd party control capabilities (RS-232 or IP based) with accessory forward-firing side-mounted loudspeakers.
2. Acceptable Products:
    a. Samsung QM85N with specified wall mount and mounting hardware as required.
    b. Approved equal.

E. Type 1 Video Projector:
1. Quiet and compact lampless (laser) high definition video projector capable of a 16:10 native aspect ratio output with 9,000 lumens brightness and 4K UHD resolution.
2. Acceptable Products:
    a. Epson Pro L1490U in finish approved by the Architect with lens as required for throw distance, supplied with specified ceiling mount and mounting hardware as required.
        1) Note: based on the design documents, and throw distance indicated, the ELPLW06 lens would be appropriate, AV contractor to verify based on actual throw distance dimension and available lenses.
    b. Approved equal.

2.10 AUDIVISUAL CONTROL SYSTEM

A. Active USB Cable:
   1. USB 2.0 active extension cable for connecting devices with USB-A connectors over long distances with data rates up to 480Mbps, built-in booster, foil and braid shielding, and integral strain relief.
   2. Acceptable Products:
      a. Tripp-Lite U026-series cable, length as required for run, supplied with adapter for connecting “female” end to connector plate.
      b. Approved equal.

B. Compact USB Power Hub (for Active USB Cable):
   1. Small form factor 4-port USB 2.0 hub providing up to 1.5A at 5V power for peripherals with external power supply.
   2. Acceptable Products:
      a. Tripp-Lite U222-004-R with mounting hardware as required to secure device.
      b. Approved equal.

C. Type 1 AV Control Panel:
   1. Wired 7-inch wall mounted touch screen control interface.
   2. Acceptable Products:
      a. Crestron TSW-770 series with mounting hardware as required in finish approved by the Architect.
      b. Approved equal.

D. Type 2 AV Control Panel:
   1. Wall mounted keypad audiovisual control panel interface with integrated audiovisual control system processor.
   2. Acceptable Products:
      a. Crestron MPC3-102-B with custom buttons and mounting hardware as required.
      b. Approved equal.

E. Type 3 AV Control Panel:
   1. Wall mounted keypad audiovisual control panel interface with integrated audiovisual control system processor.
   2. Acceptable Products:
      a. Crestron MPC3-102-B with custom buttons and mounting hardware as required.
      b. Approved equal.

F. Control System Custom Programming:
   1. General:
      a. Provide all programming for control system that includes but is not limited to story board layout, touchpanel page layouts, source code programming, and debugging of code after installation has been completed. Submit story board

layout and touchpanel layouts to architect and consultant prior to starting programming.

b. Custom software and programming for AV control system control panels and mainframes to provide control of AV devices and user-friendly control interface.

c. Product to be developed using AV control system manufacturer's programming tools and to include touch panel layouts, programming source and compiled code, and written documentation. Product to exploit full graphical capabilities of control system hardware and maximum available feedback capabilities of controlled equipment.

d. Control functions as itemized in PART 3 – EXECUTION and/or PART 1 – GENERAL.

e. Product shall conform to Owner standards, including colors, logos, etc.

2. Acceptable Products:

a. Custom software and documentation from certified in-house programming staff or other sub-contractor as approved according to Division 1. Provide touchpanel layouts as required under Part 1 – Submittals.

1) Coordinate exact requirements of the following items with Owner.
2) Provide additional software/programming as required for web browser pages.
3) Provide additional software/programming as required for iPad controls.
4) Provide asset management software/programming as required by Owner.

b. Approved equal.

2.11 RACKS, FURNITURE, & MISCELLANEOUS

A. Equipment Racks

1. General:

a. VERIFY ALL RACK SIZES, TYPES AND FINISHES BEFORE ORDERING.

b. VERIFY AND COORDINATE ALL BLOCKING AND CLEARANCE REQUIREMENTS BEFORE ORDERING.

c. Each rack furnished with permanently-mounted 3 conductor grounded AC power distribution as specified on drawings. For vertical raceways provide outlets on no more than 6" centers, extending full size of rack.

d. Each rack furnished with permanently-mounted incandescent illumination attached for ease in servicing.

e. Mounting rails with tapped 10-32 threaded holes on EIA spacing.

f. Equipment rack accessories shall be used for proper equipment/cable management, air flow, cooling, and security.

1) This may include, rack shelves, horizontal/vertical lacing bars, vent panels, blank panels, security covers, power strips, cooling fans, temperature sensors, etc.
2) Provide lacing bars, shim tabs, trim strips, security screws, and other accessories as required for a neat and complete installation.

g. Internal rack temperature shall not exceed 85 degrees. If it is observed that the temperature exceeds this threshold, notify the Architect and AV Consultant immediately.

h. Rack rail location shall be adjusted to allow the front and rear doors to close properly, and allow air space between door and front/rear venting equipment.

i. Rear rack rails shall be installed in all AV equipment racks.

j. Cables and small equipment within equipment rack shall be neatly dressed, and additionally not impede proper airflow within the rack.

k. Miscellaneous devices, including power transformers, power supplies, etc. shall be secured to internal rack shelves rather than hang from rack rails.

l. Small equipment shall be rack mounted or secured to rack shelves.

m. Security covers shall be placed over any controls not intended to be accessed by general users.

n. Blank rack space panels shall be installed in all rack openings.

o. Audio amplifiers and other heavy objects shall be installed in the bottom rack spaces.

2. Millwork AV Equipment Rack:

a. Equipment rack with rotating sliding rail system for rear access to equipment in millwork and cabinets.

b. Acceptable Products:

1) Middle Atlantic Products SRSR-4-xx Series with accessories as required.

2) Approved equal.

B. Rack Hardware and Panels

1. Blank Panels:

a. 16-gauge flanged solid steel with black smooth ended for or textured enamel finish.

b. Acceptable Products:

1) Middle Atlantic SB series.

2) Approved equal.

2. Vent Panels:

a. 16-gauge flanged perforated steel with black smooth or textured enamel finish.

b. Acceptable Products:

1) Middle Atlantic VTF series.

2) Approved equal.

3. Rack Shelf:

a. Low-profile rack-mounted fixed shelf for supporting loose equipment.

b. Acceptable Products:

1) Middle Atlantic UMS1-11.5.

2) Approved equal.

4. Exhaust Fan Kit:

a. Quiet fan kit system with 50cfm airflow and 28dBA noise rating and thermostatic probe to control fan operation, automatically turning on/off when the ambient temperature hits pre-set points.

b. Acceptable Products:

1) Lowell FW1-KITT with mounting hardware as required.

2) Approved equal

C. AC Power

1. Type 1 AC Power Strip:
   a. Single rack-space unit with a 9-foot, grounded cord, including (minimum) 6 standard three-prong AC receptacles on the back panel, plus front-panel courtesy outlet with remote controllable integrated stepped sequencing of outlets.
   b. Acceptable Products:
      1) Middle Atlantic PDS-620R.
      2) Surge-X SX-1120-RT.

D. Furniture, Mounts, and Plates

1. Type 1 Flat Panel Wall Mount:
   a. Large adjustable wall mount for flat panel displays.
   b. Acceptable Products:
      1) Chief #TM1U series, size as required to support display.
      2) Approved equal.
2. Type 2 Flat Panel Wall Mount:
   a. Swing-out articulating wall mount for flat panel displays with extension, tilt, and lateral shift.
   b. Acceptable Products:
      1) Chief Thinstall TS#25T series, size as required to support display, with mounting hardware and accessories as required.
      2) Approved equal.
3. Video Projector Ceiling Mount (for projectors under 50lbs):
   a. UL approved steel ceiling mount with adjustable tubular steel column suspended from above. Projector mount plate with roll, pitch and yaw adjustments; supports and mounting kit custom designed for designated projector; includes security lock option.
   b. Acceptable Products:
      1) Chief RPA Elite Universal series with security lock in finish approved by the Architect.
      2) Approved equal.
4. Video Projector Ceiling Mount (for projectors over 50lbs)
   a. Heavy-duty UL approved steel ceiling mount with adjustable tubular steel column suspended from above. Projector mount plate with roll, pitch and yaw adjustments; supports and mounting kit custom designed for designated projector; includes security lock option.
   b. Acceptable Products:
      1) Chief VCTU series with security lock in finish approved by the Architect.
      2) Approved equal.
5. Receptacle Back Box Covers:
   a. Appearance and finish as approved by Architect. Provided with engraved legends as specified and shown on drawings.

b. Acceptable Products:
   1) Standard NEMA Gang-Size Covers: Single or multi-gang steel covers, punched as required to receive receptacles.
   2) Custom Covers for Large Back Boxes: Min. 3 mm (1/8") thick aluminum or steel covers, punched as required to receive receptacles.

E. Cables and Connectors
   1. General:
      a. The following tables list the cabling and connectors that have been approved for the project.
      b. Cables listed below may not include all of the cabling required to complete the installation and fabrication of the audiovisual systems. The contractor may submit cable part numbers, models, and product data for cable that is not listed in the table for approval by the consultant.
      c. Connectors listed below are suggested for use with the specified cabling. The list may not include all of the connectors required to complete the installation of the systems. If a different cable is submitted for approval by the consultant, provide the appropriate connector for the cable as part of the cable submission.
      d. Supply appropriate cables and connectors for systems per the Manufacturer's recommendations, in particular for signal extension systems using extender/receiver technology.
   2. Cables:

Application	Description	Manufacturer	Model No.	Comments
Audio				
Microphone	22 AWG STP	West Penn Belden Liberty	291 8761 22-2C-SH-GRY	Equal
Microphone/Line Level (Plenum)	22 AWG STP	West Penn Belden Liberty	25291 88761, 87761 22-2C-PSH-WHT	Equal
Line Level	20 AWG STP	West Penn Belden Liberty	292 8762 20-2C-SH-GRY	Equal
Speaker Mains and Subwoofers	10 AWG UTP	West Penn	HA-210	Equal
Speaker Mains	12 AWG UTP	West Penn Belden Liberty	227 8477 10-2C-GRY	Equal
Speaker Mains (Plenum)	12 AWG UTP	West Penn Extron Liberty	25227 SPK-14 12-2C-P-WHT	Equal
Speaker Mains 70V	16 AWG UTP	West Penn Belden Liberty	225 8471 16-2C-GRY	Equal
Speaker Mains 70V (Plenum)	16 AWG UTP	West Penn Extron Liberty	25225 SPK-16 Plenum 16-2C-P-WHT	Equal

Video				
Precision Video	75 Ohm Coax RG-6U	West Penn Belden Alpha	6350 1694A 6458	Equal
Precision Video	75 Ohm Coax RG-59U	West Penn Belden Alpha	819 8241 9102	Equal
Precision Video 3G-SDI (UHD)	75 Ohm Coax RG-59U	West Penn Belden	Equivalent 1505A	Equal
Precision Video	75 Ohm Coax RG-11/U	West Penn Belden Liberty	821 9064 RG11-CATV-BLK	Equal
Trunk Lines (Plenum)	75 Ohm Coax RG-11/U	West Penn Liberty	25821 RG11-P-CATV-WHT	Equal
Control and Data				
Wireless Mic and ALS Antenna	50 Ohm Coax RG-8U	West Penn Belden Liberty	98G8 7733A RG8-CMP-BLK	Equal
Category 5e	23 AWG UTP	West Penn Belden Liberty	4245 DataTwist 1200 24-4P-L5-EN	Equal
Category 6	23 AWG UTP	West Penn Belden Liberty	4246 DataTwist 2400 24-4P-L6	Equal
Category 6 (Plenum)	24 AWG UTP	Belden Liberty	DataTwist 7882A 24-4P-P-L6	Equal
RS232/422	24 AWG STP	West Penn Belden	D2404 9925 Series	Equal
Crestron DigitalMedia	4 pr 24AWG STP (shielded)	Crestron	DM-CBL-8G-NP	No Equal
Interface Cables				
HDMI Interface Cable	High-speed HDMI Cable	Extron	HDMI Ultra Series	Equal
25' Microphone, Line, and Intercom	22 AWG STP	Whirlwind Wireworks	WMKPVC-25 C-25	Equal

3. Connectors:

Application	Description	Manufacturer	Model No.	Comments
Audio				
Mic/Line/Intercom	XLR Male Panel Mount	Neutrik Swtichcraft	NC3MX A3M	Equal
Mic/Line/Intercom	XLR Female Panel Mount	Neutrik Switchcraft	NC3FD D3F	Equal
Mic/Line/Intercom	XLR Male Inline Cable	Neutrik Switchcraft	NC3MD A3M	Equal
Mic/Line/Intercom	XLR Female Inline Cable	Neutrik Switchcraft	NC3FD A3F	Equal

Speaker	4-Pole Panel Mount	Neutrik	NL4MP	Equal
Speaker	4-Pole Inline Cable	Neutrik	NL4FC	Equal
Video				
Precision Video	75 Ohm Panel Mount	Neutrik Trompeter Kings	NBB75DFG UBJ28 KC-99-54	Equal
Precision Video	75 Ohm Inline Cable RG-6	Neutrik Trompeter Kings	NBNC75BTU11 UPL2000 Series 2065-10-9	Equal
Precision Video	75 Ohm Inline Cable RG-59	Neutrik Trompeter Kings	NBNC75BLP9 UPL-220-014 or -023 2025-51-9 or 2025-53-9	Equal
Recessed Video Receptacle	75 Ohm Pass-Thru	Canare	BCJ-JRU	Equal
Control and Data				
50 Ohm ALS Antenna	50 Ohm BNC Cable Mount	West Penn	CN-BM53-13	Equal
Ruggedized RJ-45 Cat 5 Receptacle	Ruggedized RJ-45 Panel Mount	Neutrik	NE8FDV-YK-B	Equal
Ruggedized RJ-45 Cat 5 Connector	Ruggedized RJ-45 Inline Cable	Neutrik	NE8MC-1	Equal
Ruggedized RJ-45 Cat 6 Receptacle	Ruggedized RJ-45 Panel Mount	Neutrik	NE8FDY-C6-B	Equal
Ruggedized RJ-45 Cat 6 Connector	Ruggedized RJ-45 Inline Cable	Neutrik	NE8MC6-M0	Equal
Crestron DM Connector	Shielded RJ45	Crestron	DM-Conn	No Equal
RS232 Receptacle	RS232 Panel Mount Male	Amphenol	DB9S-SFJ	Equal
RS232 Receptacle	RS232 Panel Mount Female	Amphenol	DB9S-SMJ	Equal
RS232 Connector	RS232 Inline Cable	Amphenol	DB9S-SFJ or DB9S-SMJ w/metal backshell	Equal

4. Connector Accessories:
    a. Provide matching color coded rings for receptacles (panel mount connectors) and bushings for jacks (cable mount connectors) as required.
        1) Provide different colors for various signal types (audio/video/control/etc.).
        2) Coordinate exact colors and type breakdown with Owner.
            a) If none are available from the Owner, at a minimum the following:
                (1) Green for control
                (2) Blue for video
                (3) Yellow for audio.
        3) Acceptable Products:

a) Neutrik Ethercon Accessories as required for various connectors.
b) Approved equal.

F. Labels

1. Except where otherwise specified, label as shown on drawings and as specified each item of rack-mounted equipment, all switches, controls, and receptacles.
   a. Connector and Rack Panels:
      1) Constructed of engraved and filled anodized aluminum plates.
      2) Minimum 1/8" plate thickness.
      3) Dry transfer or other types of adhesive labels not acceptable.
   b. Rack-Mounted Equipment:
      1) Labels constructed of engraved and filled plastic laminate engraving stock.
      2) Designate function and input and output line(s) or loudspeaker(s) served by labeled equipment.
      3) Key all designations to system functional and patch panel diagrams. Where possible, mount labels on blank panel directly above corresponding component. For modular equipment, provide label on inside of mainframe door identifying type of module for each slot (unless there is only one type) and gain setting as established at final checkout.
   c. Identification Panel:
      1) Install panel with 1/8"-high engraved characters on the front of the bank of equipment racks serving each space.
      2) Clearly identify the Project, System Installation Contractor, Architect, and System Designer in the following format:

PROJECT:	Owner's Name Address Room or spaces served Owner's technical support telephone
SYSTEM DESIGNER:	Acentech Incorporated 33 Moulton Street Cambridge, MA 02138 (617) 499-8000
SYSTEM INSTALLER:	Company Name Address Telephone
PROJECT ARCHITECT:	Company Name Address Telephone

   d. Receptacles:
      1) Engrave and fill receptacle label directly on mounting plate as indicated on Contract Drawings.
2. Cable Markers:

a. High-grade PVC clip-on or permanent-type cable markers with permanent markings, or printed vinyl tape protected by clear shrink tubing or adhesive wrap.

b. Acceptable Products:
   1) Electrovert Type C or Z.
   2) Brady B-702 with Alpha FIT-221 series clear tubing.
   3) Thomas & Betts EZCODER.

PART 3 - EXECUTION

3.1 GENERAL

A. All types of equipment installed by competent workers at locations shown on the drawings in strict accordance with approved shop drawings and manufacturer's instructions.

B. All equipment except portable equipment firmly held in place. This shall include loudspeakers, enclosures, amplifiers, cables, etc. Fastenings and supports adequate to support their loads with a safety factor of at least three unless otherwise stated.

C. All wiring within enclosures shall be neatly bundled, laced, and trained to terminal points with typical service loops, with no excess, using lacing bars in cabinets.

D. Take such precautions as necessary to prevent and guard against electro-magnetic and electro-static hum and to install the equipment so as to provide safety for the operator.

E. Protect all equipment, including patch panels, connectors, receptacles, racks, consoles, and video projectors, from construction dust and debris until final acceptance of the system.

F. Do not deliver equipment onsite until building is enclosed, construction within spaces where equipment will be installed is substantially complete, and installation of AV equipment is ready to begin.

G. Coordinate keying of locking devices with Owner and Architect prior to ordering mounting hardware.

3.2 SYSTEM DEMONSTRATION AND CHECKOUT (COMMISSIONING)

A. System installation will be certified complete and in fully adjusted working order by contractor. Please fill in and return Checkout verification form to schedule formal commissioning.

B. Definition of “Fully Adjusted Working Order” requires a system to be completely functional, set for normal operating conditions, and is ready to be demonstrated to the AV Consultant and End Users for training and operation. This includes:

1. Termination of all field and internal equipment rack cabling, cable labels, equipment labeling
2. Installation of control system code, testing of all devices under touch panel or button panel control, remote control panels, external control sensors, IP and network settings
3. Image adjustments
4. Audio mixing, level and equalization adjustments
5. Assistive listening tests
6. External sub-system device control (i.e. lighting or shade system interface)
7. Equipment spares or auxiliary equipment, including all auxiliary interconnecting cables and accessories

C. Confirm test results and data obtained and submitted for review during final commissioning, as requested.

D. Provide as-built drawings, manuals, and configuration software to consultant during the final testing and commissioning. System Demonstration and Testing does not define the entire scope of proof of performance of the AV systems. Detailed performance requirements are listed below.

3.3 LABELS:

A. Identify all wires and cables at every termination and connection point with the specified cable markers. The contractor is strongly encouraged to use a numbering scheme that identifies all cables terminating at patch panel jacks with the patch bay row and jack designation; use A, B, and C suffixes to distinguish multiple cables terminating at the same jack.

B. Identify switches, relays, terminal blocks, etc., with reference numbers keyed to the as-built wiring diagrams.

C. Room numbers appear on the contract documents for reference only. All labels shall reflect the Owner's final room designations.

D. All labels and legends shall be as approved on shop drawings.

3.4 MICROPHONE EQUIPMENT

A. General:

1. Excluding wireless microphones, each portable microphone provided with case, stand adapter, and min. 15 ft. cable with attached XLR-type connector.

B. Gooseneck Microphone:

1. Permanently mount to lectern, not including microphones with desktop base.
2. Locate to provide typical 6" to 12" working distance between microphone and lecturer's mouth. Notify AV Consultant immediately if microphone element is not able to be located as such.

C. FM Wireless Microphone System:

1. Orient antennas as recommended by manufacturer. Locate in positions shown on drawings.
2. Antenna Cables: Use specified cables as required for each system type.
   a. For diversity systems, use low-loss 6/U (75 ohm) or 8/U (50 ohm) cable, impedance as required. Supply RG-59 (75 ohm) or RG-58 (50 ohm) cable for short runs.
3. Except for transmitter equipment, all equipment including preamps and active combiners requiring DC power provided with power supplies are powered by receivers (battery operation is not acceptable).
4. Do not mount antennas or attached preamplifiers directly to any metal structure. Mount at least 3 ft. from any large metal object.
5. Dual-Antenna Phase/Diversity System: Use 2 antennas, both vertically oriented, observe manufacturer’s minimum required spacing.
6. Perform RF survey of site prior to installing microphone system, and notify consultant if any issues are discovered.

7. Install wireless systems such that each channel uses independent frequency. Perform follow-up RF survey upon completing installation and verify no issues or channel cross-over is present.

3.5 AMPLIFIERS AND DIGITAL AUDIO SIGNAL PROCESSORS

A. Digital Signal Processing:

1. Install all equipment to manufacture specifications and industry standards.
2. Provide DSP configuration to consultant for approval prior to programming.
3. Programming shall include all presets required for programmatic functions of space.
4. Presets shall be capable of being recalled by AV Control System as required.
5. Program system to utilize automatic microphone mixing for panel discussion type configurations.
6. Set and configure all parameters for all DSP modules within layouts. Blocks with default settings are not acceptable unless approved otherwise by AV Consultant.
7. Program system to utilize AEC, level control, and feedback suppression.
8. Provide equalization in systems such that the loudspeaker response is “flat”
9. Provide the following EQ in all loudspeaker signal paths/zones (including ALS):
    a. High pass filter
    b. Low pass filter
    c. Delay (as required)
    d. 6-Band Parametric EQ (or as required)
    e. Comp/Limiter
10. Where multiple DSP boxes are used, logically locate all portions of system flow within a given DSP box for a particular function to minimize number of “hops” between boxes. For example, all DSP modules required for function X should reside within Box A – the signal should not have to go from Box A to Box B (nor back to Box A again) in order to complete its path.
11. Verify that output levels of audio remain consistent when switching between sources.
12. Program system to utilize smallest amount of propagation delay (latency) as possible through the DSP system.
13. VoIP:
    a. Coordinate with Owner and Owner’s IT department as required.
    b. Provide dialer interface and coordinate with AV Control System programming.
14. Automatic Mixer:
    a. Initially set all input to AUTOMATIC.
    b. Adjust threshold and release time trimmers, and background threshold control so microphone inputs are actuated only when microphone is in use.
    c. Include a mix-minus for use with teleconferences and videoconferences.
    d. Limit number of open microphones.
15. Compressor/Limiter:
    a. Adjust to protect loudspeaker components from overdrive damage, and to prevent amplifiers from clipping.

b. Set attack and release rates for automatic operation.

c. Set threshold and compression controls to provide no compression with weak voice as source.

16. Conferencing Presets:

a. For rooms with audio and/or video conferencing, when there is audience participation, program the DSP system to output a signal to the AV control system to recall camera presets that are trained on specific microphone locations, triggered to that preset when the given microphone is active.

B. Gain Control and Setting Security:

1. Power Amplifiers: Provide each power amplifier with calibrated, stepped controls, which are provided with tamper-resistant covers or are located on the back or inside of the chassis (contact manufacturers for gain control security options).

2. All user-accessible devices with permanently adjusted front panel controls (that do not need to be accessed by a User to operate the system) shall be locked out or otherwise protected to prevent adjustment of settings. Such devices shall be furnished with security panels or mounted on a subpanel behind plastic vision panels for viewing of indicators such as meters or clipping indicators. This includes, but is not limited to, ALS transmitters, wireless microphone receivers, audio processing devices, control system processors, power amplifiers, etc.

C. Audio Conferencing Equipment

1. Set up digital audio signal processor for a shared call appearance between VOIP telephone interface card and VOIP telephone set provide by Owner. VOIP telephone set is to have line seize rights, with audio DSP to have barge in rights.

3.6 LOUDSPEAKER EQUIPMENT

A. Loudspeaker Mounting:

1. Carefully inspect the site to verify that no obstructions, such as beams, panels, large framing members, etc. exist between high-frequency horns and any seating area covered by the horns. Immediately notify Architect of any such obstructions.

2. Provide and install safety cable to secure all loudspeaker components and mountings.

3. Provide all structure and framework as required to properly support the loudspeakers in the indicated locations. Provide shop drawings for review prior to fabrication. Obtain the stamp of a structural engineer registered in the same state as the construction site on shop drawings which depict loudspeaker cluster structure, framework and support system(s) (if required).

4. For loudspeakers with external 70V transformers, securely mount external transformers to loudspeaker cabinets or other approved means of installing them to a static surface.

5. Paint all components and provide cloth grilles for loudspeaker enclosures as required by Architect.

B. Ceiling-Mounted Loudspeaker Enclosures and Grilles:

1. Ceiling Enclosures: Enclosures supported directly from ceiling structure in an approved manner. Support directly by acoustical ceiling tile (alone) is NOT ACCEPTABLE.

2. Grilles: Verify all grilles are installed flush with finished ceiling surface, all screws are in place and securely tightened (if applicable), and provide an overall neat appearance.
3. Flush and Surface-Mounted Enclosures: Provide enclosures as required and approved by Architect, located as indicated on drawings.

3.7 ALS EQUIPMENT

A. Infrared (IR) Assistive Listening System:

1. Locate in positions shown on drawings. Do not mount emitters behind any structural obstructions. Notify Architect and Consultant if any obstructions exist at planned mounting locations prior to installation.
2. Orient Infrared emitter panels as required by manufacturer noting mounting height, angle, coverage pattern.
3. Antenna Cables: Use specified low-loss 6/U (75 ohm) or 8/U (50 ohm) cable, impedance as required, for long distance runs.
4. Test all receivers to verify interference-free signal throughout entire area to be supported, and re-aim as necessary. If dropouts persist notify Architect and Consultant immediately.
5. Test all receivers and accessories, including headphones and neckloops.

3.8 VIDEO EQUIPMENT

A. Verifications:

1. Field verify all existing conditions regarding devices being installed. Ensure all conduit, mounting supports, etc. are supplied.
2. Field verify all sightlines are as indicated on AV contract drawings and are free from obstructions.
3. Where projection screens are installed under separate contract, verify installation at locations indicated on AV contract drawings comply with screen manufacturer’s written instructions.
4. Verify video projector lens selection, locations, and elevations shown on drawings using manufacturer's throw distance and elevation formulas for specified projector model.
5. Coordinate all submittals listed below with AV specification Part 1, paragraph 1.7.
6. Notify Architect and AV Consultant of any discrepancies or errors immediately.

B. Video Projectors:

1. Submittals:
   a. Provide plan and section drawings verifying image width, lens-to-screen distances and mounting methods.
   b. Provide detailed drawings of custom-fabricated or stock mounts and hardware.
   c. Provide detailed drawings of millwork or finish items required for specified screen dimensions.
   d. Where mirrors are required, provide detailed drawings of mounting angles, reflection rays, support structures and hardware.

e. Where projector mounts or motorized lifts are installed by others, provide drawings to guide installer indicating installation positions allowing optimal projector performance.

2. Mounting:
   a. Install projector mount and suspend projector at location and elevation indicated on approved shop drawings.
   b. Projector mounts and motorized lifts must meet all applicable safety and code requirements for ceiling mounted equipment.
   c. Fixed projector mounts must be rigid and completely free of sway or rotation deviation.
   d. Projector support pipes shall be only fixed-length pipes as required—do not use adjustable-length pipes.
   e. For ceiling-mounted installations where screen surfaces are vertical, level projector at 0° front-to-back and side-to-side.
   f. Position projector with lens centered on screen centerline in plan unless projector is provided with horizontal lens shift capability. Do not employ vertical or horizontal electronic keystone correction unless specifically authorized to do so.
   g. Wherever possible, minimize hardware and cables visible from audience seating and presenter area view points.
   h. Paint exposed mounting hardware to match room interior or as instructed by Architect.
   i. Where structural mounts or millwork openings are provided by others, verify correct positioning and dimensions before mounting projector. Provide written notification to the Owner or Architect of any discrepancies in mount positioning or stability deficiencies before projector installation.
   j. Where fixed screen millwork is provided by others, provide written notification to the Owner or Architect of any discrepancies in opening dimensions before screen or projector installation.
   k. Provide all necessary projector brackets, fittings, pipes, miscellaneous hardware and wireways.
   l. Run cabling from video projector box to projector within projector support pipe.
   m. Provide approved security cable for video projectors to accept padlock provided by owner.

C. Video Display Panels:
   1. Submittals:
      a. Provide elevation drawings showing location of video displays for approval. Where display is part of a larger graphic display, verify exact location of display with Architect.
   2. Mounting:
      a. Install display mount and display at location and elevation indicated on approved shop drawings.
      b. For wall mounted displays, provide mount to support display from blocking, if provided, or from wall studs. If a recessed box is provided behind display for

power outlets and electronic accessories, provide mount that does not obstruct access to box.

c. Wherever possible, minimize hardware and cables visible from audience seating and presenter area view points.

d. Where display is mounted in an architectural recess, verify that sufficient clearance (3" minimum) is provided for ventilation airflow.

e. Provide display mounts with security provisions to accept security locks. Coordinate lock requirements with Owner.

D. Pan/Tilt Video Cameras:

1. Submittals:

a. Provide elevation drawings showing location of cameras for approval.

2. Mounting:

a. Install camera at location and elevation indicated on approved shop drawings using approved wall mount or ceiling mount bracket.

3. Control:

a. Program control system to provide presets for principal views for each camera and provide means for users to modify presets.

E. Digital Video Transmission and Switching Systems:

1. Extended Display Identification Data (EDID):

a. Do not operate digital media transmission/switching equipment in "automatic EDID" mode, unless equipment provided has no other option.

b. Do not include resolutions in the EDID table that cannot be handled by display(s).

c. For systems where laptop computers will be used in "mirroring" mode, ensure that as many possible common resolutions are included in the EDID table without violating provision of preceding paragraph.

d. For inputs where the source is a fixed device (i.e. a fixed part of the system) create the EDID table with a single entry, again without violating provision of preceding paragraph but one.

2. HDCP Implementation:

a. For systems containing a non-HDCP-compliant display device, such as a class capture appliance or videoconference CODEC, and where switching equipment supports the capability, dynamically configure input devices for portable equipment such as laptops to report to the equipment as non-HDCP devices when the non-compliant device is in use.

F. Projection Screens:

1. Test electrically operated units to verify that screen, controls, limit switches, closure, and other operating components are in optimum functioning condition.

3.9 CONTROL EQUIPMENT

A. Audiovisual Control System:

1. Do not mount wireless receiver gateways or antennas near large metal objects.

2. Carefully coordinate with manufacturer and with Architect the dimensions and mounting conditions of all items.
3. Provide all required cable, relays, and miscellaneous hardware to interface the audiovisual control system with controlled equipment.
4. Install all components so as to use the maximum amount of any tally signals provided by the controlled equipment, including lighting dimmer systems and video playback and recording devices.
5. Mount infrared LED emitter probes to face of controlled equipment using thin layer of clear silicone caulk. Position probe to provide control of device while continuing to allow use of infrared control supplied with equipment. Secure probe cables to prevent probe from being accidentally pulled from equipment during normal system operation.
6. Set up control system hardware for rooms with identical systems identically, with control lines connected to the same terminals of the same card type with the same ID numbers, in order to facilitate initial programming and future service.
7. System shall be integrated into Owner's asset management system (i.e. Crestron Fusion) unless not required by the Owner.

B. Ethernet/IP/Local Area Network Accessibility and Control:
1. Coordinate Ethernet connectivity and IP addressing of control devices with Electrical Contractor and the Communications/Technology management of the facility. Owner will provide all required IP addresses to AV contractor.
2. Provide owner with remote control and management software interfacing via Local Area Network access from PC to any IP addressed control devices.
3. Coordinate with end-user, and Communication/Technology management of the facility, on POP-3 email notification of system service issues where desired and /or where possible. Co-ordinate with Owner and Communications/Technology management of the facility on POP-3 email of service or security issues in case of failure or disconnection of any bi-directional (e.g. RS-232 or Cresnet/Axlink) device.
4. Verify requirements of system control via IP with or Owner and Consultant.

C. Local Area Network Management Programming:
1. General:
   a. Verify requirements of room management/scheduling via IP with or Owner and Consultant.
   b. Coordinate the installation of the AV control systems with Owner and their data department, as required.
2. Room by Room AV system control:
   a. Use included software and Ethernet connectivity hardware of control systems.
   b. Provide "Enterprise" software implementation of systems unless not required by the Owner. Coordinate with AV Consultant and Owner.
   c. Program remote site portal to replicate the appearance and function of installed button control panel and touch-screen hardware.
   d. Control program can be launched locally from designated AV technician computers as stand-alone ".exe" Windows-based executable file.
3. Remote System Status Monitoring and Management Programming:

a. Use included software and Ethernet connectivity hardware of control systems.

b. Provide system-wide and room-specific monitoring and management including:
   1) Room activity and system shut-down scheduling.
   2) Multiple user level passwords, including password change and lock-out of certain user passwords at certain times.
   3) System power status including power status of rack-mounted AV equipment and display equipment.
   4) Display use (flat panel and projector lamp status), including estimated (lamp) life.
   5) Equipment connectivity/disconnect alert status.
   6) Current Source (Serial 50).
   7) Display Online (Digital 50).
   8) Occupancy Sensor (Digital 51).
   9) AV Help Desk (HelpMsg, HelpResponse).
   10) External Systems (lighting, shades, FAS, etc.) where applicable.

4. POP-3 Email Notification Programming and Set-up:
   a. Via included software and Ethernet connectivity hardware of control systems.
   b. Provide service issue notification via pre-programmed email messages to designated service accounts ONLY if requested by end-user AV support technicians and ONLY if control system includes POP-3 mail server.
   c. Coordinate with AV Consultant and Owner to determine proper conditions and destinations for email service.

D. Audiovisual Control System Programming:
   1. All control system programming shall follow the Owner's "Programming Standards".
   2. Coordinate with requirements set in all parts of this specification and the AV contract drawings for additional details.
   3. Prior to programming, submit logic and detailed panel page layouts to AV Consultant for review.
   4. Upon completion of all changes from the comments made by the Owner and AV Consultant, the Contractor will be required to make a meeting with both the Owner and the AV Consultant to demonstrate the interface on the equipment being supplied.
      a. The Contractor will be responsible for incorporating all comments noted during meeting.
   5. After the systems have been programmed, make any Owner or AV Consultant requested modifications to touchpanel page layouts or system programming as noted during final check-out and commissioning as well as Owner Training.
   6. Program system so that all devices are controlled in a logical manner, and to take full benefit of the capabilities of the Control System. Follow design guidelines for touchpanel GUI design of the Dashboard for Controls and owner standards.
   7. All programming to be performed by certified control system programmer.
   8. Program the control system as instructed by the AV Consultant and the Owner, and as indicated on the drawings so that all devices are controlled in a logical manner, and to take full benefit of the capabilities of the Control System.

9. Submit for approval changes to programming or control panels required by actual conditions (e.g. number of dimming system presets).
10. Refine and adjust, as required, programming to operate in a logical and consistent fashion. Make revisions to program as directed by the AV Consultant at checkout to correct operational inconsistencies or to properly control devices.
11. The control system will be programmed to allow the user to request help and grant permission for remote monitoring. An indicator on the screen will let the user know they are being monitored when the help desk is responding to the request.
12. Ascertain that the system is optimally programmed for smooth transitions between media uses and for minimal wear-and-tear on equipment and audiovisual media.
13. Verify that video playback device transports, etc., are stopped when another input source is selected.
14. Wherever possible utilize status feedback of source equipment, dimming systems, etc., to indicate to the control system and user the actual operating mode of the equipment. When feedback is not available (e.g. consumer playback equipment) program control system to issue commands as required to minimize status reporting errors.
15. TV tuners are to default to a pre-defined channel when selected as a source device. Include default stations as presets on touchpanel page control for device.
16. Program control system to avoid frequent powering down of video projectors by employing the standby mode to simulate turn-off with actual turn-off occurring only after a programmable delay of several hours.
17. Coordinate all fonts, colors and graphics with standards currently employed by Owner.
18. Any adjustments, revisions, modifications, etc. to the control system required for complete operation, are the responsibility of the installing contractor.
19. Make any adjustments, revisions, modifications, etc. to the control system required for complete, error-free, operation.

E. Touchscreen Control Panels:

1. Panel graphics (including text, buttons, colors, images, backgrounds etc.), as well as panel flips, sub-panels and overall screen logic flow will be submitted by the contractor to the Owner and Consultant for review and approval.
2. Touch panel graphical user interfaces shall adhere to the owner's audiovisual standards.
3. Software used for panel programming and design, and (un-compiled) programming code files will be made available directly to the end user upon request by the installing contractor at no additional charge.
4. Join numbers (other than those reserved for panel logic), hardware programming and all other installation requirements including programming software and computers are the responsibility of the installing contractor.
5. Any adjustments, revisions, modifications, etc. to the panel graphics and control system required for complete operation are the responsibility of the installing contractor.
6. Provide drawings of screen layouts of touchscreen control panels for approval prior to system programming. Indicate colors used for buttons on color panels.

7. Distinguish between primary and secondary control buttons by intensity or color. If available, use “3D” buttons to indicate button activation as visually “depressed”. Avoid excessive use of primary or other bold colors.
8. General control panel programming guidelines:
    a. Provide opening welcome screen for all systems containing institute’s seal or other appropriate graphic with label to “Touch Screen to Activate System”. Similarly, provide confirmation page to user to verify system is to be shutdown.
        1) System shutdown notification shall indicate the required amount of time before the system can be restarted, and shall allow for time for system to fully shut down and start back up again, including cool-down and warm-up time for projectors and displays.
        2) Similarly, upon system start-up, provide intermediate page with text similar to “please stand-by while the system warms up”, alerting the user that there is a required time period before the system will be fully operational.
    b. Following the “welcome” screen, provide a password page with visual feedback in the entry field so when entering a password an asterisk appears, informing the user which character space they are on.
        1) For wireless docking touchpanels, provide password protected release.
        2) Coordinate all passwords for various AV systems with the Owner and provide them with a master list of passwords. Supply that list as part of the O&M documentation.
    c. Include as part of system start-up sequence in rooms with video projectors and screens a touchpanel page that allows the user to select if it is going to be an “Audio Only” or a “Video and Audio” use. This will allow the users to be able to turn the system on and not have the projector and screen turn on/come down if the projection system is not necessary.
    d. Use of icons and graphic symbols is encouraged; however, except for certain universally-recognized icons, symbols should be supplemented with text labels to clarify meaning.
    e. Use subpages to reduce unnecessary page flips. Buttons with major consequences, such as system power buttons, should not immediately initiate the corresponding action but rather call a subpage containing a message “Are you sure you want to ...” and appropriate response buttons as a protection against accidental activation of the system function.
    f. Provide intuitive, descriptive names for source endpoints (input panels at connection plates, floor boxes, rack panels, etc.) to allow the user to easily identify which input is selected. Additionally, include a graphical representation of the room, oriented in a logical manner that indicates the devices in their relative locations. Provide similar info for source endpoints (display monitors, video projectors, etc.).
    g. Provide pages that have a static top area and side with dynamic central area.
        1) Provide persistent buttons or graphic “folder tabs” at the top of the page that include: Sources, System Power, Volume, Room Controls, and Help (and others as required).
            a) The Help button should allow the user to request assistance from the helpdesk (via control system asset management software).
        2) For wireless touchpanels in docking stations, provide a button for removing the wireless panel from the dock. Removal shall require pressing the button

followed by entering a passcode on the touchpanel to inhibit unauthorized removal.

3) Provide master volume controls on the side that include a separate "microphone" and "program" audio volume, as available within a given system.
4) The central area will be the "working" area that will become active as a main button from the top is selected. For example, when the "Sources" button is selected, the central area will display a list of sources available for selection. Once a given sources is chosen, there will be a page flip to a new page that will display the functions available for that source, such as transport controls for the Blu Ray player.
5) All sub-pages in the central area will have a "back" or "return" button allowing the user to get to the previous page, as well as a "home" button that brings them directly to the top-level.

h. Provide "Room Controls" page for separately controlling:
1) Screen/projector or display separately from rest of system when it is being used for audio only.
2) Lighting system presets, as applicable.
3) Shade systems, as applicable.

i. Provide preview window of all video sources with touch to enlarge to full screen.
1) Applies to "Flat" and "Tiered" classrooms only for this project.

j. Provide a "Technician" page accessed by press and hold on "date/time" are of panel for 10 seconds. Page to include the following:
1) Display controls
2) Lamp Hours
3) Force input controls
4) Video mute

k. All transport controls shall behave similarly, whatever the behavior of the transport's front-panel controls (e.g. PAUSE will only have effect when transport is in PLAY; pressing PAUSE again or the PLAY button will resume play and un-highlight PAUSE).

l. Verify that output levels of audio remain consistent when switching between sources.

m. Provide stand-alone application to duplicate all control panel functionality for each room using IP protocols over Ethernet.

n. Program control systems to provide email notification to "helpdesk" persons designated by the Owner when projector lamps fail or reach 90% of their rated life.

o. Program control systems to turn off audiovisual systems after defined period of time of control system inactivity. Length of time period to be coordinated with Owner.

p. Program system to query status of video displays, or in some other way elicit a communication response from displays, at time intervals not to exceed 15 seconds. If projector fails to respond (i.e. the projector has been disconnected) control system shall send email notification to persons designated by the Owner and route alarm tone to the system loudspeakers, turning on audio equipment as

required for the purpose. Canceling of alarm tone to be provided on a "technician" control page.

q. When the AV system is turned off, the projection screen(s) will be raised, all controlled equipment with the exception of the video projector will be turned off, and countdown timer for video projector shutdown started. Timer will operate similarly to paragraph "c" above but will have its own separate time setting.

r. Program control system management software to automatically turn off all AV systems at a pre-designated time, coordinated with the Owner. Program systems to display a touchpanel page alerting the user to this condition, in the case that the system is legitimately being used after that time, requiring user provide feedback to delay turning off of that system. The system, if selected to be left "on", should be set to recursively try again every hour afterward.

s. Verify that any button presses on local devices (such as "Play" on a Blu Ray player) tracks on the associated touchpanel(s) for rooms that are divisible when being operated in a "combined" mode.

t. Verify that all stops (PTZ camera mounts, projection screens, motorized lifts, etc.) are in place and are appropriate.

u. Program the control system to display on the respective touchpanel control pages the local IP address for audio conferencing calls via VoIP and the video codec for videoconferences. Include dialer directory/phonebook and make available on touchpanel pages.

v. Program control system to provide keypad input method for channel selection for TV tuners. Also include preset channels as buttons for quick recall. Coordinate stations with Owner.

w. Program control system to provide individual inputs on Digital Input transmitters as individually selectable inputs.

x. Coordinate the integration of the control system and the management software with the Owner and AV Consultant.

y. Control system, audio signal processors, and digital video switch equipment will connect to the UPS where these devices are specified. Control system shall communicate with UPS device. In the event of a power outage, after one minute has passed, control system shall instruct the other UPS-connected devices to shut-down properly in order to protect their programming. After power is restored, user will be required to restart system from control panel.

9. Specific control panel installation & programming guidelines:
    a. Desktop Control Panels:
        1) Install wired control panel and/or wireless control panel base station in countertop or lectern as required.
        2) Verify size and mounting conditions with Architect.
        3) Except for AC power, all wiring contained in single multi-core cable (or in overall heat shrink sleeve) and terminated in single specified multi-contact receptacle.
        4) Provide portable panels to Owner as part of Portable Equipment turnover.
    b. Wall Mounted Control Panels:
        1) Install control panel and/or docking station in associated back box. if back box is provided by others, verify back box prior to installation.
        2) Verify size and mounting conditions with Architect.

F. Interface with Other Systems: The audiovisual system shall connect to the Lighting Control System, the Shade Control System, and the Fire Alarm System (FAS) as identified on the drawings. Systems connected to the FAS shall have the audio and video signals “muted” when triggered.

3.10 AV NETWORK SECURITY

A. All equipment to be configured to prevent unauthorized users from access to the systems and network and prevent disclosure of confidential information.

B. Default passwords of internet connected audiovisual equipment are readily known and can be used as a means to access network equipment by unauthorized users. AV networked devices may include any device with a wireless or wired Ethernet port.
    1. Assign role based access control with different levels of access and permissions for each user type:
        a. Admin – Ability to make changes to network, security configurations, and user accounts.
        b. AV Configuration – Ability to make changes to AV Parameters.
        c. System User – System operation only.
        d. Others as required by the Owner.
    2. Change all passwords from default values to project specific passwords. Follow industry recommended password strength standards when choosing new passwords.
    3. Provide new passwords to the Owner.
    4. Provide instructions to change passwords.

C. Data Network Switches in AV systems:
    1. Do not connect unauthorized AV network switches to the Owner’s LAN.
    2. Provide logical separation of AV and IT networks through hardware and VLAN’s.
    3. Disable unoccupied ports and services on managed switches.

3.11 RACKS, CABLES, CONNECTORS, AND MISCELLANEOUS EQUIPMENT

A. Wiring and Interconnections:

1. General:
    a. Exercise care in wiring to avoid damage to cables and equipment.
    b. Make all joints and connections with rosin-core solder or approved mechanical connectors, except mechanical connectors are NOT acceptable on microphone lines. Connections to transformer leads for distributed loudspeakers may be made using properly-sized wire nuts or nylon-insulated pigtail crimp connectors. Wire nuts are not acceptable except at individual loudspeakers.
    c. All connections to screw-type terminals shall be made using spade lugs. Bare or tinned wire is not acceptable.
    d. All connections to lugless compression-type screw terminals shall be made using bare wire only. Do not tin wire.
    e. All wiring executed in strict adherence to standard broadcast practices. This includes:
        1) Dress cables in conveniently sized bundles, combed into parallel runs, either laced or banded with sufficient plastic ties.
        2) For equipment mounted on glides, or otherwise requiring servicing from the front of the rack incorporate a cable "service loop" of sufficient length to permit the equipment to be pulled forward from the rack for servicing.
        3) Support cables and bundles with sufficient plastic ties and support bars to ensure that no strain is placed on any connections or connectors.
        4) Organize cables and cable bundles behind patch bays to permit easy access to the patch panels to add or remove cables.
        5) Place cable markers 3"-5" back from video connectors to permit easy viewing. Do not bind markers into cable bundles.
    f. All audio signal lines carried by twisted-pair cable and switched with two poles per line unless noted otherwise. Do not tie one side of audio line to other audio lines.
2. Grounding:
    a. Ground equipment, racks, and audio line shields to independent audio system ground ONLY as shown on drawings. If not shown on drawings, ground case of power striplines in equipment racks to the racks and directly to isolated ground buss in the power panel or to power system ground at the building AC service entry only.
    b. Ground all conduits ONLY to power system ground. Insulate all conduits and electrical boxes from sound system, including equipment racks and audio system ground.
    c. Insulate all conductors in conduit, including shields, from the conduit, back boxes, and from each other for the entire conduit length.

3. Equipment Racks:
    a. Install equipment in racks to permit access to all equipment for service. Transformers, relays, terminal blocks, etc., mounted in rear of racks behind other equipment shall not prevent access to equipment connections or shall be mounted on hinged panels to permit access.
    b. Wire all racks completely in the shop. No internal rack wiring to be done on the job site.
    c. Install equipment in racks with ventilating panels as required to provide adequate ventilation and according to equipment manufacturer's recommendations.
    d. Connect all microphone, DC control, and line level cables to equipment racks via specified audio terminal blocks. External lines to patch bay terminated directly on patch bay terminal blocks.
    e. Connect loudspeaker lines with equipment racks via specified terminal blocks. Use spade lugs if barrier strips are used. Do not buss commons together. Do not ground.
    f. No signal or control lines shall leave a rack without connecting via terminal blocks.
    g. Provide unused panel space with blank or ventilating panels.
    h. Locate patch panels at least 30" above floor.
    i. Locate free-standing racks as indicated and to provide access to rear without moving racks.
    j. For permanently located racks containing equipment on glides, with desk/control surfaces, or which may be unsteady from cantilevered devices or personnel, bolt all racks to the concrete floor slab (through the access flooring if necessary).
    k. Bolt adjacent racks together on at least 3 locations along both the front and rear edges.
    l. Equipment racks not bolted to the floor because of service access with "Anti-tip" bases, casters and brake.
4. Wall-Mount Equipment Racks:
    a. Drywall Partitions: Before installation of drywall material, install blocking or other bracing required to support weight of equipment rack.
    b. If internal wall bracing is not provided before wall is closed in, install ¾” plywood mounting plate secured with drywall screws to at least three separate studs. Size of plate and number of mounting screws as required to support weight of rack. Paint plywood to match wall finish. Uni-Strut or similar steel support frame attached to structure is also acceptable.
5. Cables in Conduit:
    a. Run all lines in metallic conduit or wireways unless otherwise indicated. Run microphone level, line level, loudspeaker level, and DC control wiring each in separate conduit.
    b. Do not locate AC power lines in conduit containing audio or video lines.
    c. Do not splice lines in conduit.
6. Exposed Cables:

a. Line level or mic level lines exposed above countertops (such as those lines serving mixing consoles, program source equipment, etc.) shall be rubber-jacketed, AWG #20 two conductor with braided shield such as Belden 8412 or equivalent. Plastic or vinyl jacketed cables are not acceptable.

7. Receptacles:
   a. Wall-mounted receptacles in metal boxes at building standard receptacle height unless otherwise indicated.
   b. Floor-mounted receptacles in flush floor boxes with flush lids.
   c. Catwalk-mounted receptacles in metal boxes mounted on catwalk hangers at building standard receptacle height.
8. Balanced Receptacles:
   a. Attach connectors to mounting plates with machine screws unless using single-hole mounting types with threaded sleeve and mounting index to prevent rotation.
9. Unbalanced Receptacles:
   a. Install jacks to mounting plates with insulating washer and sleeve to electrically isolate the jack from the electrical box and conduit.
   b. Install isolation/balancing transformers in electrical boxes or wireways adjacent to each unbalanced receptacle as indicated.
   c. Wire input receptacles to short the line except with connector inserted.
10. Video Receptacles: Install feed-through BNC receptacles to mounting plates with insulating washer and sleeve to electrically isolate the receptacle from the electrical box and conduit.
11. Loudspeaker Wiring:
   a. Functional Diagrams and/or Conduit Drawings indicate required home runs for all loudspeakers and loudspeaker zones. Home run requirements depend on line power loss as well as functional considerations and shall be strictly adhered to.
   b. Loudspeaker lines above ceilings installed using specified UL listed plenum-rated cable. Lines are to be installed as high as possible, directly to undersides of floor or to roof decks above, using strain reliefs, cable ties, or other approved method to attach lines securely and neatly to building structure. Lines installed loosely or otherwise on top of ceiling tiles, ductwork, etc., are NOT ACCEPTABLE.
   c. Floor-to-floor lines installed using specified UL listed plenum-rated cable. Attach lines securely and neatly to building structure.
12. Fiber Optic Cables:
   a. Terminate fiber optic strands with connectors compatible with connectors on equipment and with fiber optic cables provided.
   b. Use of compatible quick-connection system is recommended (e.g. Corning UniCam® Pretium Installation Tool Kit for Corning fiber cable; Belden FiberExpress System or West Penn Wire Fiber products with Optimax Installation Tool Kit).
   c. Neatly coil surplus fiber cable using bend radius larger than manufacturer's minimum bend radius and secure to rack to prevent crimping or damage to cable, or provide rack-mount fiber management

3.12 SYSTEM PERFORMANCE TESTS AND ADJUSTMENTS

A. Test all equipment to verify conformance with manufacturer's performance specifications and with this specification.

1. Verify all systems meet the requirements identified in this section or otherwise within the contract. Use the Avixa Audiovisual Systems Performance Verification checklist.
2. Adjust all systems as required to conform with testing requirements for any failed tests.
3. Provide results of final, re-calibrated system testing to Architect and AV Consultant for review and approval prior to scheduling of commissioning testing by AV Consultant or any user training provided to Owner.

B. Audio Systems:

1. Absolute Impedance:
   a. Set any loudspeaker level controls at zero attenuation. Measure absolute impedance value of each loudspeaker line at 250, l000, and 4000 Hz, without amplifier connected but with all loudspeakers connected. Impedance shall be at least 90% of rated load impedance of respective amplifier. Check resistance of lines to all loudspeaker and microphone receptacles, with receptacles open and short circuited.
2. Hum and Noise Level:
   a. Adjust gain controls for optimum signal-to-noise ratio and full amplifier output with -55 dBm level at a microphone input and 0 dBm at line-level input.
   b. Without changing gain, terminate microphone and line-level inputs with shielded resistors of l50 and 600 ohms, respectively.
   c. Measure overall hum and noise level at each power amplifier output for each input channel. Level shall be at least 80 dB below rated power output of amplifier over a bandwidth of 20-20,000 Hz.
3. Electrical Distortion:
   a. Load power amplifiers with resistors matching nominal impedance of output terminals used in system in place of actual loudspeaker loads.
   b. Adjust gain controls as for hum and noise level tests.
   c. Apply 1000 Hz size-wave signal from an oscillator having less than 0.l% total harmonic distortion to each microphone and line-level input at level required to produce measured full amplifier output.
   d. Distortion shall measure less than 0.l%.
4. Parasitic Oscillation and RF Pickup:
   a. Set up system for each specified mode of operation.
   b. Use 50 - 100 MHz bandwidth oscilloscope and loudspeaker monitoring.
   c. Check to ensure that system is free of spurious oscillation and RF pickup in the absence of any input signal and also with system driven momentarily to full output at l60 Hz.

5. Buzzes, Rattles, Distortion:
    a. Apply high-quality music signal to the system. Adjust the system for frequent peaks at its specified maximum sound pressure level.
    b. Apply sine-wave sweep from 50-50,000 Hz at 6 dB below full amplifier power.
    c. In both cases, listen carefully for buzzes, rattles, and objectionable distortion.
    d. Correct all causes of such defects. If cause is outside the system, promptly notify the Architect and his Consultant, indicating cause and suggested corrective procedures.
6. Level Balance: Adjust level controls for all items of similar equipment for identical measured voltage gain.
7. Measure system acoustical performance using a sound level meter set for "slow" meter damping except as otherwise noted, and flat response with random incidence at a height of 4 to 5 feet. All interior finishes and furnishings shall be in place, and system gain shall be adjusted to provide levels of 70 to 80 dB and at least l0 dB above background noise at the measuring locations for these tests, except as otherwise noted. Include the following tests and adjustments:
    a. Frequency Response:
        1) Measure loudspeaker frequency response with all control equalization set for flat response, using l/3-octave bands of filtered pink noise centered on ANSI preferred frequencies, or broadband calibrated pink noise measured in l/3-octave bands using a calibrated real-time analyzer.
        2) Adjust equalization to provide average system response within ± 3 dB of a response (0 dB) which is flat from 63-2500 Hz and slopes uniformly from 0 dB at 2500 Hz to -5 dB at 10,000 Hz.
    b. Uniformity of Coverage:
        1) Use 4000 Hz octave band of random noise as test signal output to loudspeakers.
        2) Lateral Uniformity: ± 2 dB at all positions equidistant from front of hall.
        3) Front-to-Back Uniformity: Decreasing linearly within ± 2 dB from 0 dB at front of hall to -6 dB at rear as measured on the hall center line.
    c. Maximum Output Level:
        1) Measure with standard "fast" meter damping.
        2) Loudspeaker Cluster: Capable of providing 95 dB SPL in the audience area on axis of any high-frequency horn and employing wideband recorded music as a test signal.
        3) Distributed Loudspeaker Systems: Capable of providing 95 dB SPL on axis of any loudspeaker and using wideband recorded music as a test signal.
    d. Propagation Delay:
        1) Provide signal propagation delay through DSP system platforms.
8. Final RF survey results (for wireless microphone systems, and others as required).

C. Video Systems: Test the video system following the approved Proof-of-Performance Test Plan to verify that it meets these minimum performance requirements. Submit the recorded test results with Test Reports.
    1. Video Standards:
        a. Frequency Response: ± 0.5 dB, 60 to 4.l8 MHz.

b. Crosstalk: -40 dB at 3.58 MHz.

c. S/N Ratio: 45 dB, DC to 4.l8 MHz, unweighted, peak to RMS.

d. Hum: <10 mV peak to peak.

e. Line and Field Tilt: 2% with 60 Hz square wave.

f. Differential Gain: 1% at 3.58 MHz, l0-90% APL.

g. Differential Phase: ± 1° at 3.58 MHz, l0-90% APL.

h. Envelope Delay: ± 0.l microseconds, 0.2 to 2.1 MHz; ± 0.05 microseconds at 3.58 MHz.

i. Color Production: Primary and Complementary Colors (R, G, B, Cy, Yl, Mg) at 75% saturation within inner 50% of the of inner boxes (± 2.5°) when viewed on vectorscope.

j. Signal Levels: 1 V p-p, ± l IRE, at 100% peak white color bar.

2. Audio Standards:

a. Frequency Response: ± l dB, 30-l5,000 Hz.

b. Hum and Noise: -80 dBu, 30-l5,000 Hz, unweighted.

c. Distortion: 0.25% THD, 30-l5,000 Hz.

d. Signal Levels: +4dBu.

3. System Calibration: Calibrate each video display system as follows:

a. Allow projector or flat panel display to warm up for a minimum of 30 minutes.

b. Turn off all video enhancement circuitry options including image overscan.

c. For projected displays align the image with the black borders of the screen:

1) If the display uses a variety of aspect ratios use the zoom lens to align the image with the black borders of the screen. If the image does not fill the screen (e.g. a 16:9 screen with 4:3 image) then align top and bottom of image with black border of screen.

d. Set factory color temperature to warm, D65, or other setting to achieve closest approximation to 6500°K color temperature. Set sharpness control to minimum.

e. Adjust black level and video gain:

1) Reduce ambient light to less than 2 foot-candles of ambient light on screen.

2) Using the PLUGE (Picture Lineup Generating Equipment) pattern from the signal generator, adjust the brightness (brightness control on most displays) until the “blacker-than-black” bar is visible on the screen and then decrease brightness until the bar just disappears.

3) Using the grayscale pattern from the signal generator, adjust the contrast control so that the highest grayscale transition disappears and then decrease contrast to make the transition just visible.

4) Repeat steps b and c as required for stabile results. Record control settings.

f. Adjust color level or gain:

1) Display SMPTE color bar test pattern. Shut off red and green channels on display or use a blue filter to observe the display.

2) Adjust the blue color level until the outer row large blue bars blend with the patch underneath.

3) With only red channel operating or with red filter check red balance. Repeat for green channel. If red and/or green balance is significantly out of balance, make minor changes to color and tint controls to achieve best compromise for color control settings.
4) Record control settings.

g. Adjust sharpness:
1) Using the S802B or similar pattern, adjust sharpness control for maximum sharpness without ringing (duplicate lines).
2) Record control setting.

h. Brightness, Uniformity, and Contrast Ratio: Perform measurements with room lighting at representative viewing level (typically 7fc in seating area).
1) Using the ANSI 9-zone pattern and a spot photometer, measure screen brightness in each zone. Calculate screen brightness as the average of the nine zones and uniformity as the maximum variation from the average.
2) Use the ANSI 16-zone checkerboard test pattern and viewing locations measure the contrast ratio of representative white squares vs. adjacent black squares.
3) Record all measurements.

i. For display systems employing identical equipment (same model number), measure and adjust three representative samples as specified above. If control settings for both displays are in close agreement, controls of remaining identical displays may be set to same values without further testing, unless resulting performance is visibly different from the first two.

D. Digital Video Signals: Provide the following information for systems employing HDMI and/or digital media signals:
1. The number of KSVs (HDCP keys) supported by each digital source device.
2. The video timing (e.g. 1080p 30 fps Deep Color or 1366x768 30 Hz), HDCP use, and audio format of each non-portable digital source when operating.
3. The native video timings and supported audio formats for each connected sink.
4. The video timings and supported audio formats presented in the EDID of sinks to each source – indicate the preferred video timing. Ensure all EDID tables are consistent across same model products.
5. The length of cable used on all HDMI or shielded twisted pair cables used for AV distribution.
6. The data rate supported by each shielded twisted pair cable used for AV distribution.

E. Video Projectors:
1. Provide written verification of completion of the above procedures.
2. Provide a printed table of memory location mapping. Include memory number, name, resolution, and vertical and horizontal scan rate.
3. Download memory map set-up data to personal computer and provide backup diskette to owner.
4. After completion of projector set-up, record the following items for inclusion in pre-acceptance test reports:
a. Current lamp life hours shown on projector (include date).

b. Provide security service code if required by owner.
c. Set-up software version number.
d. Projector, input modules, and decoder card serial numbers for each system.
e. Date of manufacture.
f. Date of installation.
g. List of supplied accessories (remotes, lens caps, tools, cables, backup discs, owner's manuals).
h. Date of next scheduled convergence touch-up visit.

F. Control Systems: Test each function of each control station or touch panel to verify proper operation and that each illuminated switch and indicator operates properly when the associated function is selected.
1. Verify the system is programmed to conform to requirements set in sections above.
2. Verify all button presses operate the command that is specified by the button labeling.
3. Verify that all needed control sequences are present for the user on the control interface.
4. Walk through the space and verify that the portable or wireless control interfaces will work throughout the entire space the device was specified for.
5. Check proprietary network connectivity (Cresnet/DMnet/AxLink) for proper levels.
6. Verify data network connectivity for each master control device.
7. Verify that all master control devices are reporting to the monitoring server.

G. Connection Points: Verify system input and output point is functioning properly and correctly passes signal.
1. System Inputs include, but are not limited to, floor box, rack panel and receptacle panel inputs, as well as directly connected source devices.
2. System Outputs include, but are not limited to, floor box, rack panel and receptacle panel inputs, as well as directly connected endpoint devices (projectors, monitors, speakers, etc.).

H. Test Reports and Certificates: Submit results of all tests and adjustments conducted above and certification that the installation is complete and ready for checkout as specified under SUBMITTALS in PART I - GENERAL.

3.13 FINAL ADJUSTMENTS AND ACCEPTANCE TESTS

A. Upon approval of the contractor's test report, and at a time set by the Architect, assist the AV Consultant(s) in performing final system adjustments and acceptance tests. Provide all labor, material, tools, and measurement equipment necessary for these tests and adjustments, including the test equipment and material specified in Article 1.1, except as otherwise specified.

B. The contractor shall supply sufficient representatives for assisting in performance of these tests, all of which shall be thoroughly familiar with all details of the system, and shall include the field supervisor in overall charge during the course of the installation work.

C. Budget 16 working hours for the performance of these tests and adjustments. If final acceptance is delayed beyond this period because of installation not in accordance with these specifications, pay for all additional time and expenses of Consultant(s) during any resultant extension of the acceptance testing period.

D. Acceptance tests may include speech intelligibility, display contrast and uniformity of operation of each system under various operating conditions, using various live or recorded materials.

E. Measurement of frequency response, distortion, noise, or other characteristics may be performed on any item or group of items deemed necessary to determine conformity with specifications.

F. Adjustments: Adjust the system as instructed by the AV Consultant. Adjustments may be required to any portion of the system including:
   1. Loudspeaker aiming.
   2. Audio equalization and level balance, including audio DSP programming.
   3. Display contrast, brightness, and color content, including EDID and video transport system setup (flat panels and projectors).
   4. Timing and functioning of the audiovisual control system, including touchpanel programming or page graphics.
   5. Video projector alignment with screen image area.

End Of Section

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PART 1 - GENERAL

SECTION 28 00 00

SECURITY

A. CONTRACT DOCUMENTS

1. Attention is directed to the AGREEMENT AND GENERAL CONDITIONS and all Sections within DIVISION 1, GENERAL REQUIREMENTS, which are made a part of this Section of the Specifications.
2. Furnish labor, materials and methods required to provide the complete Security System work, in first class condition, as indicated on the Drawings and specified herein. Coordinate all devices in filed including conduit, wiring, and connection to 120 VAC sources provided elsewhere in Division 16.
3. The standard access control system for Cornell University is LenelS2 OnGuard.
4. Cornell University will provide network video recorder(s) and storage and will be located off premise.
5. Cornell University will provide their own network PoE network switches.
6. Refer to security drawings for video surveillance camera locations and access control devices.
7. Prepare Shop Drawings for all system components and submit to general contractor, architect and engineer for approval prior to ordering materials. Ordering materials prior to submitting for approval or comment or lack of approval or comment does not indemnify contractor from removing and replacing materials or devices that have not been approved.
8. Verify all dimensions and conditions at job site.
9. Provide templates or special instructions of installation requirements to applicable trades of the Construction Manager, Contractors for General Construction, including but not limited to Masonry, Architectural Woodwork, Hollow Metal and Wood Doors and Frames, Store Front/Curtain Wall, Entry/Special Doors, Overhead Rolling Doors, Misc. Metals and Architectural Metals Contractor, Hardware Supplier, Elevator Contractor and Electrical Contractor.
10. Coordinate template distribution with GC.
11. Supply, install, make operative, and test, the system and its components in accordance with applicable codes, local authorities having jurisdiction, manufacturers' recommended practices, industry standards, the Construction Manager, Engineer, Owner, Architect or their representatives, these Specifications, and the Drawings.
12. Make final adjustments, calibrations and programming modifications as directed by the Authority Having Jurisdiction, Construction Manager, Engineer, Owner, Architect or his designated representative, other system equipment manufacturers, and demonstrate all systems for acceptance.
13. Furnish documentation, including approved Shop Drawings, product data, test reports, programming sequences, database input, operators, maintenance and installation manuals, and As-Built Drawings, in final "Project Manuals", for Owner's use.

14. Provide instruction and training for the Owner's security staff, operating personnel and maintenance personnel. Warrant all new equipment, wiring, and components for a period of one year from accepted written date of turnover.
15. Maintain and service the new equipment for a period of one year from the written accepted date of turnover.
16. Provide complete manufacturer/factory assisted system design, specification, installation instructions and sizing of all system equipment and insure proper annunciation and operation, programming configuration and cabling requirements to ascertain that all specified functions will be provided and all devices shown will be integrated into the security system, and supported by the manufacturers and/or their licensed representatives for guarantee and warranty services.
17. Where contract documents provide dissimilar information as it relates to security system and installation mounting heights of all card readers, intercoms, local audible alerts, video surveillance cameras and IDS keypads, confirm, with the project engineer, that locations, as shown on the Drawings, comply with current ADA standards on this project.
18. Program card access control system, intrusion detection system, and video surveillance system with user defined database requirements and specified operations contained herein.

B. RELATED WORK SPECIFIED IN OTHER CONTRACTS

1. See Sustainability 01 81 13.
2. Metals 05 00 00.
3. Rough Carpentry 06 10 00.
4. Finish Carpentry 06 20 10.
5. Acoustical Ceilings 09 20 00.
6. Heating Ventilation and Air Conditioning 23 00 00.
7. Communications 27 00 00.
8. See Division 6, rough finish carpentry, and coordinate size and location of plywood backboards at security panel locations to accommodate mounting of all required security panels, trough, etc.
9. See Division 6, wood and plastics for coordination of security equipment placement at all reception desks, administrative office areas, and installation details for mounting, service and wiring.
10. See Division 8 of the contract documents, Doors and Windows, for all associated details of doors and frames, as pertinent to selection of magnetic contact device type, placement and mounting in frames and doors and associated back boxes, wiring pull and/or junction boxes.
11. See Division 8 of the contract documents; Finish Hardware for details relating to door/ frame hardware and preparation, electrified locks, power transfer devices, lock power supplies, door lock/unlock control panels and required coordination to accommodate these components and/or systems, lock voltage and current draw coordination with lock power wire gauge interface and integration with ADA power operated doors, and any other related equipment and/or requirements.

12. See Division 9 of the contract documents, Finishes, for details relating to acoustical ceilings and gypsum board systems, floor finishes, painting, etc. For information pertinent to device and back box selection and installation.
13. See Division 26 of the contract documents for all specifications governing the performance of work associated with the installation of raceway (conduit, EMT, cable trays, wire mold, trough, etc.), system junction and pull boxes, and device rough-in boxes, for all Security System work shown on the Security Drawings. Conduit and outlet box for security system are provided by Division 26.
14. See Division 26 of the contract documents for all work related to supplying 120 VAC power for hook-up to any security system equipment requiring it.
15. See Division 26 of the contract documents for information relating to the fire alarm system and, as required, relay interface to interrupt power to electric locked doors, so that they may be remotely released.
16. Review all other specification sections, as required, to achieve complete inter-trade coordination.

1.2 SUBMITTALS

A. Shop Drawings and Samples:

1. Shop Drawings for all equipment and floor plan areas, coordination issues and drawings, as called for in this Section, shall be required to be submitted to the General Contractor.
2. It is the intent for the security system contractor to prepare and submit, as a single submittal, complete equipment and cable shop drawing, and coordinated conduit and wiring drawing package. All security drawing submittals shall be submitted electronically unless otherwise requested.
3. Partial submittals of cable, conduit drawings, and equipment/components, will not be reviewed. They will be returned “Rejected” for non- compliance with the submittal requirements of the contract documents.
4. The Drawings and Specifications are intended to supplement each other so that any details or equipment shown on the Drawings and not mentioned in the Specifications or vice versa shall be executed the same as if mentioned in the Specifications and shown on the Drawings. Shop Drawings shall reflect this coordination of Drawings and Specifications.
5. All Shop Drawings submitted shall be checked by the Contractor for all clearances and field conditions, including, but not limited to, plumbing piping, HVAC and related equipment, architectural finishes, access door locations, light locations, millwork construction, electrical connection, distribution and equipment, HVAC duct and register sizing and locations, glazing details, door and frame details, rolling grille details, misc./louvers/grilles, elevator controls, elevator equipment, etc., as required to insure shop drawings reflect “to be installed” coordination.
6. Shop Drawings shall be created by the Contractor, manufacturer or manufacturer’s designated representative. If created by the Contractor, they shall be submitted to and reviewed by the manufacturer or their designed representative and include a statement on the Drawings that this process has occurred and that the Shop Drawing reflects the approval of the configuration to work in accordance with these specifications and manufacturer’s standards.

Manufacturer's installation instructions shall be submitted for each piece of equipment and/or system.

7. The Contractor shall submit, for approval, in accordance with General and Supplementary General Conditions, Shop Drawings of the equipment being provided which shall include, but not be limited to, the following:
   a. Magnetic contact switches, all types as required, showing mounting installation detail for all door, hatch and rolling door and grille types in this project, dimensioned door and frame preparation (template) requirements, conduit and box system,
   b. End-of-line resistor and wire terminations, and interconnect to intrusion detection panels
   c. Alarm point monitoring field multiplex panels (remote input modules) and/or card access multiplex panels.
   d. Electrified door hardware
   e. REX contacts
   f. Door lock/unlock panels
   g. EMF/Surge suppressor device placement, and connection to access control field multiplex panel and tamper switches.
   h. Obtain these exit-wiring diagrams from and include details of coordination with the project's Division 8 hardware supplier.
   i. Low voltage power supplies and transformers for intrusion detection security devices with load calculation, circuit wiring, battery back- up calculations, and supervisory monitoring circuit connections to the intrusion detection panel, loss of AC and low battery alarm inputs to alarm point monitoring panel, etc.
   j. Card readers.
   k. Complete information on remote (field located) card reader access control devices.
   l. Card reader and cards.
   m. Request-to-exit devices.
   n. Fire alarm release interface/functions.
   o. Interface to ADA power operated door controls, etc.
   p. Provide electric lock, power supply and door lock/unlock control release button wiring diagrams, and power transfer hinge and/or knuckle information and ADA power operated door control schematics. Assure proper installation techniques, voltage requirements, power supply sizing, back EMF protection, sequence of operation and fire system's interface from Division 16 and fire alarm equipment supplier, etc.
8. Complete access control system's applications software description, database programming description, describing all specified and provided system capabilities for this project, indicating use of system software programming features, utilizing card access transactions programming on a reader-by-reader basis, in matrix format, etc. Also, complete operating system hardware platform and network requirements, event printer information and system hardware, software information and how they are integrated into the access control system network. Also, provide a special statement of communications

compatibility between the access control system software and the video surveillance system front end.

B. Complete video surveillance system with all required:

a. Cameras
b. Lenses
c. Housings
d. Poles
e. Mounting supports
f. Video, control, signal and power wiring
g. Power supplies
h. 120 VAC surge suppressors.

1. Connection to door locking/unlocking electrified door control panel including power supply, access control system interface, remote electrified door locks, system cable requirements, point to point wiring diagrams, a complete text sequence of operations, installation, test and set-up instructions, connection to card access system field multiplex panel, etc. Also, show back box and conduit details.
2. 120 VAC Line conditioning and surge suppression and UPS equipment, complete with load side capacity calculations, load side power connection diagrams, line side connection, disconnect means, regulation and filtration criteria, alarm output to intrusion detection system, etc.
3. Conduit and wire routing drawings of all work in ceilings, walls and floors.
4. Any other component of system as specified herein or as called for in the Drawings, or as required to achieve specified system operation. Provide large-scale drawings (1/2" = 1'-0") of primary security equipment.
5. Shop Drawings shall be reviewed and pre-approved by system and equipment manufacturer's engineering department for complete system including all wiring, devices, power requirements, agency listings, manufacturers' ratings, environmental operating criteria, and operating performance characteristics, prior to submission to Architect. Shop Drawings shall be stamped by factory engineer indicating approval of submitted configuration with Contract Drawings, and will not be reviewed without factory stamp or approval letter.
6. All Shop Drawings and samples shall be returned to the Contractor for corrections and additional information and shall be resubmitted, properly corrected, and with required supplemental information.
7. Drawings shall contain all corrections made by the Engineer, or the manufacturer's engineering department, prior to, or as part of, approval process, and shall satisfy all requirements of the Specifications.
8. Under no conditions shall the contract drawings be re-titled, or otherwise reprocessed, and used as a Shop Drawing submission.
9. Sample Boards & Mock Ups
10. Immediately after approval of shop drawings, this Contractor shall create, on site, an installation "sample board" with each intrusion detection, duress, access control, and communication devices, mounted on the actual, to be used, back box and extension ring, complete with wire and or E.O.L. terminations and tagging to represent final mounting, conduit and wiring

connection and identification methods for HU and Engineer's approval. Approved sample board shall be the standard for fieldwork inspection and quality control and used as reference for the balance of the project.

11. Contractor shall also mock up one of each typical video surveillance camera and mounting kit, contractor must mount unit on same or similar mounting surface where unit will be installed.
12. Samples of each system device, as reflected in Shop Drawings, for return to the Contractor, as follows:
13. Each type of magnetic contact switch
14. Card reader and access control card
15. Camera, typical dome
16. Each type of cable, adequate length to show factory cable ID marking, each label for intended use in system
17. Wire tags
18. One of each type of cable connector – individually labeled with intended use.
19. One sample of each, to be submitted with shop drawings and prior to installation of conduit, pulling of wire, construction of interior partitions, or commencement of finish work, in or on which the device is to be installed, to provide coordination detail requirements with other trades. Samples shall be returned for Contractors' use after review period. Samples may be assembled on site for Engineer's review to minimize shipping. All samples shall be present for a single review session by the Engineer.

C. Coordination Drawings

1. The Contractor shall create field installation Coordination Floor Plan Drawings which specifically convey the required conduit size and cable routing to accomplish specified system operations using conduit, equipment and cabling submitted in the Shop Drawings, factory installation requirements, engineering calculations, sample board, and coordinated with all other trade work, as represented by Shop Drawings for other trades.
2. The Security Contractor shall advise the Construction Manager, Electrical Engineer and Electrical Contractor of any additional 120VAC requirements prior to electrical rough in to insure a cost effective coordination of this work where not shown on the contract drawings.
3. Where device or equipment relocation (other than security panel locations) to a position, other than that shown on the Security Drawings is required, as a result of coordination with other trade work, relocations of up to 15 feet shall be provided at no additional cost or credit to the Owner.

D. As-Built/Record Drawings

1. The Contractor shall create and maintain in accordance with the General Conditions and this Section, the following evidence of the "as-built" condition of the project.
2. The Contractor shall maintain on the job site one complete dedicated set of Drawings and Specifications on which all items which are part of the system's installation and all changes of materials, equipment, or dimensions from the contract documents or shop drawings shall be recorded and kept current on a

daily basis and shall be made available to the Engineer at all times during the construction process.

3. The Contractor's schedule of amounts for monthly contract payments as required by the General Conditions shall include an allowance for preparation and delivery of the required As-Built.
4. Upon completion of the work, Contractor shall furnish final As-Built Drawings showing work as actually installed, to be submitted as a part of the "Project Manual".
5. Submission shall be signed by the Contractor with a certification attesting to correctness, and marked "As-Built", and dated, with Contractor's title block. Final submission shall also be provided on disks, using REVIT 2018 or latest version at time of creation.
6. As-Built Documents shall include, but not be limited to, showing the following details:
    a. Rigid and flexible conduit size, location, and dimensional offset from column lines. Entire system piping shall be shown. This shall include in-slab and underground conduit, used for security cabling.
    b. Conductor size, type, color and numerical codes, and numbers in raceway, as well as all plenum cable or wiring run outside of conduit system.
    c. Systems type identification, circuitry and zoning numbers of conductors.
    d. Size and type of raceway and cable and its in-site placement within the structure, using dimensions and architectural "landmark" references (column lines) wherever possible.
    e. Type of device, and cable installed (manufacturer, model number, functional description) and spares remaining.
    f. All monitor and control equipment panels locations and type, size, capacity and spares remaining.
    g. All back up battery power supplies, type, low voltage side connection circuitry, and 120 VAC side circuit no., panel and connection type.
    h. All security system equipment shown on the contract documents, approved shop drawings, or otherwise utilized as part of the system installation, and associated connection diagrams to equipment provided herein, provided by other trades, or connected to Owner-provided equipment.
    i. Interface drawings to other systems such as fire alarm, and power operated doors, etc.
    j. Control equipment internal module schematics, including electronic assemblies, interface wiring, and external field device signal, power, and circuit wiring.
    k. Areas of equipment application and zones of detection, and location of equipment, complete with site designations, room names and numbers, door numbers, etc. Review room and door names and numbers with the Construction Manager prior to submission
    l. A legend explaining all abbreviations and details.
    m. In addition, any other information as required by the Engineer to adequately describe the "as-built" condition.

n. This Contractor shall create his As-Built Drawings in such a manner so that the As-Built Architectural conditions are referenced and used as backgrounds. It is the intent to incorporate the Security System As-Built work into the overall building Contract Architectural As-Built Drawings.

o. The As-Built Drawings made by this Contractor must therefore incorporate the information identified on those prints.

p. CAD plot thin line architectural floor plans may be made available by the Architect for this purpose, upon written request. Contractor's option is to obtain equivalent CAD disks of floor plans from The Engineer. In either case, the Contractor shall create floor plan backgrounds for As Built accordingly.

q. Use manufacturer's printed information where applicable, otherwise obtain or generate written instructions. Where control panel connection/wiring diagrams are provided by the manufacturer, include as part of the as-built drawings and modify "factory generic" connections to the specific conditions for this project.

E. Permits

1. The Contractor shall take out and pay for all permit applications, licensing fees, and submit any working drawings required by applicable sections and required by all approving authorities, and in accordance with applicable sections of the General Conditions and project Specifications.

F. Test Reports

1. Test reports are required for the work of this Section. These reports shall be submitted to document pre-acceptance factory equipment "burn-in" test, as well as documentation of all site tests performed for final system functional checkout and acceptance. Two test reports shall be submitted as required for review and record documentation purposes.

G. INTENT

1. It is the intent of the Specifications and Drawings to call for finished work, tested, ready for operation and programmed specifically for this site and Owner's requirements.
2. Any apparatus, appliance, material or work not shown on Drawings but mentioned in the Specifications, or vice versa, and any incidental accessories necessary to make the work complete and perfect in all respects and ready for operation, even if not particularly specified, shall be provided without additional expense. Coordinate with each system manufacturer to insure all hardware, firmware, relays, or other necessary components are provided prior to bid submission.
3. Minor details not usually shown or specified but necessary for the proper installation and operation, shall be included, the same as herein specified.
4. In all cases wherein apparatus herein referred to in singular numbers, it is intended that such reference include as many such items as are required to complete the work.
5. Specifications are of simplified form and include incomplete sentences. Words or phrases such as "the Contractor shall", "shall be", "furnish", "provide", "a", "an", "the", and "all", may have been omitted for brevity.

6. Work under jurisdiction of the State and local Fire Marshal (electrically locked door control systems) shall comply with requirements set forth by the Fire Marshal.
7. The latest edition of NFPA Sections 70, 72, and 101, and local Building, Fire and Electrical Codes, and associated amendments to same, shall be the minimum requirements for all conduit, wiring, and access control/electrically locked door system related materials, methods and operating functions.
8. Additional requirements of local authorities having jurisdiction shall be provided as required to achieve system approval and sign off.
9. Nothing contained in the drawings and specifications shall be construed to conflict with applicable State and local laws, codes, and ordinances. Comply with drawing and specification requirements, which are in excess of minimum code requirements.

H. EQUIPMENT SUBSTITUTIONS

1. Refer to Division 1 of the General Requirements for stipulations governing the substitution process. In addition to terms and conditions identified therein, requests for approval will not be considered unless they are submitted and are accompanied by, minimally, the following information:
2. Complete literature, performance, and technical data describing the proposed equipment, including size, power requirements, detection, reporting, and programming capabilities, wiring requirements, installation, maintenance and performance criteria, limits or constraints on operation, listings and labeling by Testing Agencies, compatibility with integrated systems, etc.
3. Substitutions shall not be considered if they are not accompanied by simultaneous submissions of the specified equipment.
4. Substitution specifications will not be reviewed unless an item-by-item physical and electronic performance comparison to the specified product is provided to allow a complete comparison of products/systems to the Engineer’s satisfaction.
5. The Owner reserves the right to refuse any substitution on the basis of its requirement to maintain a uniformity of equipment purpose, function, maintenance and service, to achieve compatibility with other portions of the installation, or aesthetic requirements as dictated by the Engineer, or otherwise at the complete discretion of the Engineer.

I. BASE BID

1. Contractor shall set forth the Base Bid total cost for a complete installation of the specified system components, all work completed.
2. Refer to the Security System Drawings and these Security Specifications and balance of the contract documents for other base bid requirements.

J. MAINTENANCE AND SERVICE CONTRACT PRICING

1. Contractor shall submit with his Bid, a contract stating the amount to be added to the Base Bid if maintenance and service is provided as called out herein. This price identification shall remain valid and available for Owner acceptance until expiration of 1st year guarantee and warranty.
2. Contractor shall submit, at the time of bid, as a document separate from bid proposal responding to the Specifications, a contract for maintenance of newly

installed equipment and response to emergency service calls which contract details the proposed maintenance and service to be provided subsequent to expiration of first year guarantee and warrants.

3. Such contract shall provide for preventive maintenance inspections and tests of system and sub-system components on a regularly scheduled basis (Minimally, 2, bi- annual inspections and tests) to accommodate the Owner's requirements for efficient and reliable operation of the entire system. Emergency service response shall be provided within twenty-four (24) hours of receipt of telephone call or fax from a representative of the Owner for such service.
4. Such contract shall identify all costs to the Owner for such service and response and should identify costs for total contract for a minimum of one (1) year of such service, and stipulate renewal rates for service for a minimum of one year after termination of first year of service.
5. As part of this maintenance and service agreement, the Contractor shall include two (2) bi-annual inspections and complete device-by-device and complete system operational tests of the installed system to verify proper operation of every aspect of the system and all of its components. Test reports shall be provided to document test and corrective procedures/results.
6. Maintenance and service agreement shall stipulate hourly rates for business hours and overtime hours, travel rates and reimbursable expenses, spares, stocking requirements, and a "return-to-on-line" performance path that identifies time and equipment performance milestones and contractor service and management staff dedications and equipment resource dedications to minimize and define "time-off-line" without opportunity for ambiguity. These line item cost and corrective performance identifications are a minimal requirement.
7. Provide this agreement and submit with the Base Bid documents. The price for this agreement shall remain valid for one year from the date of Owner acceptance of the security system (expiration of first year guarantee and warranty). It shall be the Owner's option to execute the maintenance and service agreement at any time up to expiration of first year guarantee and warranty.
8. Failure to submit the maintenance and service agreement may serve as the basis for Base Bid dismissal.

K. TEST AND ACCEPTANCE

1. This Contractor shall carry all time, equipment, manpower, etc., to provide the required tests for the project. Tests shall be conducted in two distinct categories: Factory Tests and Field Completion Tests.

L. Factory Test

M. Factory tests of individual components shall be provided. If manufacturers do not provide such tests, contractor shall bench test equipment at their shop prior to delivery to site.

N. The primary systems listed below shall be configured at the contractor's office in such a manner to insure primary system hardware, firmware, and field communication and control panels operate prior to arrival on site.

a. Access Control System

b. Video Surveillance System

c. Provide documentation of factory tests by submitting copies of factory test sheets, which can be unequivocally identified as the test report for equipment shipped to the job site.

O. Field Completion Test

1. Tests shall be made of the completed system under conditions simulating as nearly as is practically possible, final installed conditions using actual system components. These tests shall show conclusively that the requirements of the Contract Documents have been fulfilled, and as required in this Specification Section.
2. Documentation: Keep full and thorough records of all tests, in tabulated, permanent reproducible form, completely indexed and explained, indicating the specific test performed, participants, environmental conditions such as temperature and humidity, date of performance, results obtained, corrective actions taken (if any), (and by whom), final results, and comments if required.
3. Copies of all tests shall be delivered to the Construction Manager, Engineer or his designated representative prior to scheduling final system acceptance test. Identify all malfunctions as either work performed under this contract or under another contract.
4. Costs associated with the repair of equipment provided by the Contractor and found faulty in the test process shall be the Contractor's responsibility.
5. All instruments, ladders, scaffolding, lifts, testing equipment and labor required for all tests shall be furnished by the Contractor.
6. The operation of individual components of equipment as part of these tests does not constitute a final acceptance of the work by the Owner. The final acceptance is to be made after the Contractor has adjusted his equipment and demonstrated that it fulfills the requirements of the Specifications and Drawings, all punch list items are completed and retested/inspected, successful completion of Owner's acceptance test, and the systems have operated for 15 consecutive days without fault or failure, as complete, operational, on-line systems. Should a fault or failure occur, in a particular system, the 15-day period shall commence again after the required repair, for that system.
7. Upon completion of the installation and prior to acceptance, the Contractor shall thoroughly clean (internally and externally) all equipment furnished and/or installed under this Section.
8. All systems shall be restored by the Contractor to full operating capacity and operating capability after testing.
9. The Engineer or his/her designated representative shall be notified in writing of all scheduled tests at least 15 business days in advance, so that he/she may witness same. Un-witnessed tests shall be performed again at no expense.
10. Should the Contractor not pre-test the system prior to making official notification of being ready for the final acceptance tests, and should a final test be conducted and malfunctions or unfinished work be evidenced, the cost of retesting and professional travel and inspection fees shall be borne by the Contractor.

11. The Contractor shall complete his work in a timely manner and coordinate with the Construction Manager to accomplish tests for final acceptance during business hours (8 am - 5 pm), Monday through Friday. Should tests need to be conducted after hours or on weekends or holidays, due to improper scheduling of work, premium costs for design professional oversight shall be borne by the Contractor.
12. Prior to the final “Turnover Meeting Acceptance Test”, the Contractor shall provide a system “initial check-out” test. Each system component shall be tested alone and for system operation and shown to operate successfully. It is the intent of this test to check out all systems to establish any system failures or faults prior to the final tests in the presence of the Owner or his designee. Manufacturers’ requirements, engineers, or factory/dealer support shall be solicited and obtained by the Contractor to insure all systems perform as specified herein and per manufacturers’ requirements.
13. Upon completion of the installation and system “Initial check-out” test, a “Turnover Meeting Acceptance Test” shall be held at the site at which the Engineer or his designee, Construction Manager, the Owner, system equipment suppliers, and all associated Sub Contractors are present. The manufacturer’s representatives shall also be advised and their presence requested in writing for attendance. At this time, a functional test of the entire system and all its components shall be demonstrated.
14. Functional test shall include all security sub-systems and their components, communication with the central station and its equipment and any interfaced systems.
15. Complete operation of the individual building’s intrusion detection panels and keypad arm/disarm partition status display system, and its interface to the intrusion detection and access control systems.
16. Intrusion detection fully functional and operates in accordance with project specific, Owner-approved and contractor loaded database.
17. Complete operation of video surveillance system, and its interaction with the access control and intrusion detection system.
18. Complete operation of battery and standby power systems, including all battery power charging circuits, and proper equipment function of all low voltage power supplies and the UPS system.
19. Prior to gaining approval to conduct final “Turnover meeting acceptance testing”, the installing Contractor must provide the Construction Manager or his designee with a preliminary test report, (from “Initial check-out” test) enumerating each component of each system tested and showing satisfactory results, as achieved during “initial check-out” test.
20. After completion of installation, and as part of “Initial check-out” tests, and prior to “Turnover meeting acceptance test”, a factory-trained technician shall test and certify each system’s operation. Testing shall also certify that equipment is installed in accordance with approved factory means and methods.
21. A letter of certification indicating that each system functions and conforms to all specifications herein shall be presented to the Construction Manager, Engineer or his designee prior to “Turnover meeting acceptance test”, as part of the “Initial check-out” test documentation.

22. Prior to “Turnover meeting acceptance test”, the Contractor shall provide one complete set of the approved equipment shop drawings and wiring diagrams for use by the Engineer or his designee during the “Turnover” test process.
23. In order to facilitate the final “Turnover” meeting test, the Contractor shall prepare “Test Site/Floor Plans” which give the alarm point monitoring panel security zone address of each intrusion detection device, each partition component identity of the IDS systems, CCTV camera number, card reader circuit address, and each emergency communication station so that immediate recognition of device tested and system reaction can be verified as part of the final “turnover” test.
24. As-Built drawings shall be available during the final turnover meeting test so their accuracy can be verified by the Engineer in the field.

P. DEFECTS

1. Should it be found that material furnished and installed under this Section fails to comply with the Contract Documents, it shall be rejected and replaced in accordance with the General Conditions, by the Contractor, and all work disturbed by changes necessitated in consequence of said defects or imperfections shall be made good at the Contractor’s expense. Particular attention is called to the installation details of most equipment, making replacement more difficult than initial installation. The Contractor is cautioned to check out all devices for function before installation.
2. Only new products and equipment shall be utilized for this Contract. Refurbished, reconditioned, repaired or components used in any way shall be considered “defective” and rejected from the project.

Q. GUARANTEE AND WARRANTY

1. The Contractor shall guarantee and warrant in accordance with the General Conditions, all work called for in the Contract Documents. Date of Owner acceptance will be the date of first day of first year guarantee and warranty, as well as maintenance and service, as called out in these Specifications.
2. The Contractor shall secure warrants from all equipment suppliers and provide the Owner or its designated representative with copies of each, for each piece of equipment, as part of the “Project Manuals”. Each warranty and guarantee shall state that all work performed will be free from defects in materials and workmanship for a period of one (1) year from date of final written acceptance by the Owner, unless guarantees for longer periods are provided by equipment suppliers or required elsewhere in these Specifications. The warranty and guarantee shall state that any defects in workmanship and/or materials appearing in the work or operation of system or components of system within the prescribed time will be corrected without costs (labor and material) to the Owner within two (2) days after receipt of written notice from the Owner, if such defects or faults do not prevent proper operation of the system, and shall further agree to repair or replace any and all damages to the system caused thereby at any time or times during the guarantee period.
3. If detection, reporting, access control, arming/disarming communications, or video surveillance system operation is compromised, provide emergency 24 hour, service response as outlined below.

4. (Particular attention is called to the fact that the Contractor is to include the necessary maintenance [labor and materials] to all the system equipment and components to provide for this one-year warranty in his Base Bid. Validity of the one year warranty requirement is not to be voided, canceled, or shortened by any requirements for special or additional service, during the first year of operation, after the date of system acceptance.)
5. The Contractor shall be responsible to provide, during guarantee and warranty period, emergency service response, including labor and materials, within twenty-four (24) hours of receipt of telephone call or fax for service from the Owner. Such response shall be required for calls placed regardless of hour, day or night, business day or Holiday. Such emergency service response shall be for repair of system component failures, wiring faults, or other system related circumstances, which compromise functional performance.
6. Where acts of God, negligence and abuse, acts of vandalism or other such occurrences cause damage to the system, emergency maintenance and service agreement shall stipulate hourly rates for business hours and overtime hours, travel rates and reimbursable expenses, spares stocking requirements, and a “return-to-on-Contractor service and management staff dedications and equipment resource dedications to minimize and define “time-off-line” without opportunity for ambiguity. These line item cost and corrective performance identifications are a minimal requirement.

R. OWNER TRAINING

1. Contractor, as part of this work, shall train no fewer than fifteen (15) designees of the owner’s staff in the operation of the equipment, prior to final systems’ acceptance.
2. Such training shall include instruction in automatic and manual operation of all system components and equipment. Training shall be provided by qualified, factory trained and certified technicians familiar with each sub-system’s operations and shall be provided at the site for a period of no less than twenty four (24) hours of instruction to fifteen (15) persons, as follows:
3. Operator level training shall include course material minimally encompassing the following:
4. Sequence of operation review of all systems
5. Sign on-sign off, all systems
6. Selection of all displays and reports
7. Commanding of all input and output points, keyboard and mouse mode
8. Commanding of all card reader, access control addresses, keyboard and mouse mode
9. Commanding of all video surveillance controls
10. Input of/creation of English language text reports
11. Use of all dialog boxes and menus
12. Interaction with the NVR’s systems interface
13. Supervisor level training shall include on-site instruction, encompassing all of the above, plus:
14. Graphic user interface (GUI) creation and modification for IDS/CA and video surveillance systems

15. Purge and/or dump of historical data
16. Creation and modification of cardholder database
17. Password assignment/modification
18. Modifying alarm limits and start-stop times
19. Operator assignment/modification
20. Download and initialization of remote panels
21. Point disable/enable, access/secure schedules
22. Troubleshooting of sensors (determining bad sensors)
23. Use of report software with system data
24. Creation and modification of all site-specific user-defined fields
25. English language text programming
26. System's manager programmer level training shall include onsite training, encompassing all of the above, plus:
27. Software review of Sequence of Operation and flowcharts
28. Use of diagnostics on site
29. System maintenance procedures
30. Review of initialization
31. Upload/download on off-line archiving system software
32. Factory diagnostic routines, on-line with manufacturer
33. English language text programming
34. Scheduling of Owner training prior to completion of the work shall be coordinated with the Owner. Training sessions shall be provided at the Owner's option and availability. Training sessions may, at the Owner's option, be spread over a six-month period.
35. The Contractor shall arrange training sessions at least 15 business days in advance to accommodate trainee schedules of availability.
36. The Contractor shall provide a training agenda, including all required pictorial and any other required training material to Owner fifteen (15) business days prior to the training session. The training agendas shall be provided to the Engineer for preliminary review prior to their submission to the Owner.
37. The specified system training manuals shall be provided a minimum of ten (10) business days in advance of training sessions to provide adequate time for staff training preparations.
38. The Contractor shall provide the services of factory trained and certified instructors who will give full instruction to designated personnel in the adjustment, operation and maintenance, including pertinent safety requirements, of the equipment and system actually installed.
39. Instructors shall also assist in the development of the system's required database creation, through an interactive dialogue of text, system displays, and oral training/example sessions with the Owner's security staff until adequate familiarity is obtained by the Owner to participate in the completion of the database by the Contractor.
40. The training shall be based on the system installed rather than being a general (canned) training course. Instructors shall be thoroughly familiar with

all aspects of the subject matter he/she is to teach, and of this system as installed. An agenda of subject matter and hours devoted to it shall be provided ten (10) days in advance to allow Owner scheduling of staff participation.

S. PRODUCT HANDLING AND PROTECTION

1. Deliver, store, handle, and install all devices and system equipment, to prevent damage. Deliver materials in their original unopened containers, cartons, and packing, unless “prior-to-delivery” bench testing was performed, in which case boxes shall be marked “bench tested”. Store where protected from damage, from exposure to the elements, and theft.
2. Turn over operation and installation booklets contained in equipment shipping boxes to the Owner as part of the “Project Manuals”.
3. Coordinate with the General Contractor and the Owner or his designated representative for site access and availability of lockable and secure storage.
4. Where installation of security system equipment occurs prior to completion of space, provide temporary protection of all equipment to maintain “as new” condition.
5. Loss of inventory due to theft, vandalism, etc., shall be the Contractor’s responsibility until written system acceptance date.
6. The Contractor is responsible for protection of all stored or installed materials, equipment or systems until the written date of accepted turnover. Damage from vandalism, theft, lightning, or other acts of God or man shall be repaired by the Contractor to the specification and drawing standards and requirements at the Contractor’s expense.

T. ENVIRONMENTAL CONDITIONS

1. Do not store, install, or expose, prior to, during, or after installation, any Security System device or device or control panel equipment, in an environment in which the temperature drops below 45ºF, rises above 95ºF, or comes in proximity to or contact with strong magnetic fields, corrosive fumes, paint, static electricity, dust, moisture, etc.
2. Check all 120VAC feeds for clean power, clean grounds, hi/lo voltage and amperage, etc., prior to any equipment connection.
3. Check all cables for shorts, grounds, induced voltages or other spurious noise, which could adversely affect system components or performance, prior to connection of any signal transmission equipment.
4. Protect all equipment from other construction activities such as dust, paint, and sealers, using non-damaging protective means.
5. Protect all equipment, devices and cables installed to achieve protection from other contractor activities.
6. Protect all equipment from lightning and voltage surges. Damage due to lightning strikes or voltage surges prior to system acceptance shall be repaired by the Contractor at his own expense.

U. JOB COORDINATION

1. The work specified under this Contract requires complete coordination with the work of other trades working under separate contracts. Special attention is called for coordination with the appropriate trade contractor in the preparation

of drywall, masonry, wood, steel, concrete, and other general construction details, the Electrical Sub-Contractor for connection to the 120 volt AC system, and the installation and layout of the security system conduit and required electrical boxes and trough box, the Hollow Metal Manufacturer and Hardware Supplier for access control door unlocking system, electrified exiting hardware control and door contact preparation, the Hardware Supplier for the provision of the electrified door unlocking hardware, and the elevator contractor for cab mounted equipment. It shall be the Contractor's responsibility to initiate, generate, maintain and respond to all such coordination efforts, with these and other trades.

2. This Contractor shall dedicate whatever time is necessary in working with the appropriate Contractors for General Construction, Millwork Contractors, storefront/aluminum curtain wall fabricator and installer, Electrical Contractors, Hardware Suppliers, Door and Frame Manufacturers and Installers to insure coordination of Security System equipment, wiring, and conduit layout for the purpose of achieving the installed system as shown on the Contract Drawings.
3. Special attention is called for concerning coordination of hollow metal door and frame suppliers, hardware suppliers, Electrical and Security Contractor in placement of all devices, wiring, and door and frame preparation for door contacts, access control system equipment, wire terminations, cable selection, conduit routing and mounting of all associated equipment.
4. All doors and frames scheduled to receive magnetic contact devices shall have them recess mounted. This Contractor shall provide all details and wiring information to the Door and Frame Suppliers to insure recess mounting of contacts, concealment of wiring, and maintenance of factory guarantees and fire and sound rating labels.
5. Access control door unlocking system equipment and electrified hardware shall be wired strictly in accordance with manufacturer's instructions provided by the Hardware Supplier, access control manufacturers, and lock power supply manufacturer.
6. Any wiring through hollow metal, aluminum or wood doors and/or storefront construction shall be through factory or "providing-trade" raceways. Security contractor shall coordinate with other trade divisions and fabricators to insure these raceways are provided and sized for wiring approved in the Security System Shop Drawing submissions.
7. Intercom stations, as well as card readers, shall be mounted on walls and conduit and wires routed through same in a manner approved and supervised by the wall contractor and Construction Manager to maintain wall integrity, waterproofing, moisture/vapor barriers.

V. QUALIFICATION OF BIDDERS

1. Bidders must submit details of their qualifications to undertake and complete this Project along with their bid to the general contractor. Declarations of qualifications must list installations of equal cost and technical scope; must represent evidence of seven (7) years of experience in installing and servicing of intrusion detecting systems, access control systems, CCTV systems, etc.; must represent experience in project site area (within 100 miles of site); and maintain a crew of maintenance and service personnel capable of providing the specified guarantee and warranty service. In addition, the Contractor shall provide written documentation of his current State license, indicating date of

renewal and any qualifications. The Contractor must also document any factory-authorized affiliation with the manufacturers of specified equipment.

2. A single prime Contractor shall be responsible for all work of this Section and as shown on the Security Drawings. The Contractor shall make whatever arrangements are necessary with an Electrical Contractor for conduit and box work and all wiring to insure a complete bid price for the entire raceway system (conduit, back box network, wire mold, etc.)

W. SUPERVISION OF WORK

1. The Contractor shall furnish the services of an experienced Foreman who shall be constantly in charge of the installation of the work. Foreman shall have a minimum of 10 years experience in the installation of similar security systems equipment, and shall have equivalent skills and training of a licensed Master Electrician.
2. The Foreman shall be qualified and authorized to make decisions and answer questions asked by the Engineer, Construction Manager or Owner or his designated representative regarding progress and details of the work.
3. The Contractor shall perform all work under the supervision of representatives of the manufacturer(s) of the new systems equipment. Costs for such supervision shall be borne by the Contractor and included as necessary in the Base Bid.

X. JOB CONFERENCES

1. A pre-installation Job Conference shall be convened including the Architect, Construction Manager, Engineer, Electrical Sub-Contractor, Hardware Supplier and Installer, Storefront Door Installer, Security Contractor and other parties deemed necessary, in order to insure a complete coordination of the security system work and its impact on other trades.
2. A security system coordination job conference shall be conducted at the time of security shop drawing submission by the Construction Manager to insure coordination of the security shop drawings prior to their submission to the Engineer.
3. Job conferences shall be held as required while construction is in progress. Contractor shall attend, or be represented at such meetings. Should the Contractor elect to be represented, it is to be understood and agreed upon that in dealing with Contractor's representative, the full assurance that such representative's actions and commitments may be accepted the same as though the Contractor who signed and is bound by the Contract, were himself present and personally made such agreements and commitments, in accordance with all terms and conditions of the Contract Documents. Representation will only be allowed if approved, in advance, by the Construction Manager, Engineer and Owner.

Y. REFERENCE STANDARDS

1. When standards of the Federal Government, the State, the City, trade societies, or trade associations are referred to in the Contract Documents by specific date of issue, these shall be considered part of the Contract. When such references do not bear a date of issue, the current published edition at date of First Invitation to Bid shall be considered as part of this Contract, including supplements thereto.

2. Codes and Regulations, In addition to the codes and regulations identified in the Division 1 General Requirements and Division 16, the following codes and standards shall be adhered to and shall not be contravened without approval from the Engineer or Governmental Agency having jurisdiction:
    a. All Federal, State and Local codes governing (latest issue)
    b. NFPA 101: Life Safety Code (especially Section 5, Means of Egress)
    c. NFPA 70: National Electrical Code
    d. ADA: American Disabilities Act
    e. ANSI: American National Standards Institute
    f. ASTM: American Society for Testing & Materials
    g. NEMA: National Electrical Manufacturers Association
    h. EIA: Electronic Industry Association
    i. UL: Underwriters' Laboratories, specifically:
    j. UL 294: Access control system units
    k. UL 1076: Proprietary burglar alarm system units

Z. Notify the Owner and the Engineer or his designated Representative of any materials or apparatus believed to be inadequate, unsuitable, in violation of laws, ordinances, rules or regulations of authorities having jurisdiction.

AA. In case of differences between Building Codes, State and Federal laws, local ordinances, rulings by the authority having jurisdiction, and utility company regulations and the Contract Documents, the most stringent will govern.

BB. The minimum standards for system equipment installation and configuration to be the recommendations of each manufacturer.

CC. Should work be performed which does not comply with the requirements of the applicable building codes, State and Federal laws, local ordinances, industry standards and utility company regulations, changes for compliance shall be performed at no additional cost to the Owner.

DD. All material and equipment shall conform to the applicable NFPA, UL, NEC, EIA, ANSI, ADA and NEMA Standards and Requirements.

EE. If any additional requirements of the Owner are identified after bid award, the consequences of any requested modifications shall be reviewed in a meeting between the Owner, Architect, Construction Manager, the Engineer, and this Contractor, for the purpose of obtaining a cost and time schedule impact.

FF. Refer to Division 1 and 16 for further code and regulatory agency requirements.

GG. Ratings of devices and equipment specified without reference to specific performance criteria shall be understood to be nominal factory or nameplate ratings or performance criteria established by means of industry standard procedures and manufacturer's specifications.

HH. FINAL ADJUSTMENTS

1. The Contractor to the complete satisfaction of the Engineer or his designated representative, the authority having jurisdiction and the manufacturer's

representatives shall accomplish the adjustments of the system(s) and components.

2. The Contractor shall advise the Owner of any access codes, keys, program settings, factory default codes, used during set up and testing, etc., and shall invalidate same at system acceptance time, only after turnover of complete documentation to the Owner, and the provision of proper systems use training, as directed by the Owner's Project Manager.

II. ACCESSIBILITY

1. Locate all equipment, which must be serviced, operated or maintained in fully accessible positions, especially when located in concealed locations. If required, for better accessibility, advise the Construction Manager to authorize the trade in which the access door will be mounted to furnish access doors for this purpose, after coordination with the Engineer.
2. Minor equipment location deviations from Drawings may be made to allow for better accessibility, but changes of magnitude or which involve extra cost or exposing equipment, shall not be made without prior approval.
3. Minimum clearances in front of or around equipment shall conform to the latest applicable manufacturers requirements for inspection and testing, and the NEC for control panel and junction box access, (treat all control panels, power supplies, etc., pull and junction boxes, for access, as though they were 120 VAC leaving a minimum of 3'-0" clear in front of same, floor to ceiling).
4. All Security System equipment, except wiring and conduit, shall be completely accessible without the requirement to remove any portion of building structure or other system component, except a man-sized access door or ceiling tile.
5. Enclosure access doors shall be hinged and arranged to allow full swing open and complete access to all enclosure components and wiring.

JJ. NAMEPLATES (NOT SIGNAGE)

1. Each major component of security equipment shall have the manufacturer's name, address, and model number and rating on a plate securely affixed in a conspicuous place. Nameplate of a manufacturer's representative or a distributing agent will not be acceptable. FCC, UL, EIA, NEMA, or other Code ratings, or other data, which is die- stamped into surface of equipment to be positioned in an easily visible location.
2. Provide plastic laminate labels on all terminal or equipment cabinets, power supplies, control panels, and control equipment, to clearly identify device number, system type, function, operation, and status.
3. Labels for all equipment shall be submitted to the Owner for approval, and all labels shall be reflected on the as-built drawings for all respective equipment.
4. Laminated plastic shall be 1/8" thick Melamine plastic, blue with white center core. Surface shall be a matte finish. All corners shall be square. The characters shall be accurately aligned and engraved into the white core. Size of nameplates shall be 2" by 3" minimum. Provide larger nameplates where text requires. Characters shall be in accordance with "Arial" letter style standard or approved equal.
5. Labels shall be securely affixed using screws or rivets. Two-sided adhesive tape will not be accepted.
6. SPECIAL EQUIPMENT AND CONNECTIONS

7. Furnish all fittings, conduit associated with panel to panel and panel to trough connections through wire ways, boxes, hangers, wiring devices, enclosures, signage, fasteners, connections, control panels, relays, and miscellaneous accessories necessary for the complete installation of the Security System and final connections to equipment furnished by other trades and/or the Owner.
8. Furnish engineering support, project management coordination, and develop detailed diagrams which identify the required wiring interface between the vehicle gate control and card reader system, ADA power operated doors and card reader system, and delayed exit locks, their power supplies and the fire alarm system.
9. Engineering Drawings are, of necessity, schematic for systems equipment as exact roughing requirements vary slightly with different manufacturers and job conditions. The Drawings represent an accurate, but schematic, depiction of the Security System conduit and wire network layout for the system equipment specified. However, final conduit and wire quantity, size, and arrangement, as well as final routing, and placement, may vary based on the shop drawing approval of system equipment, manufacturer's engineering requirements, field coordination with other trade work, and as a result of other trade equipment which must be connected to.
10. The Security Contractor shall furnish and install wire and shall connect to all equipment indicated on the Drawings and as required by the manufacturer and the approved shop drawings at no additional expense to the Owner. The Security Contractor shall advise the electrical contractor of any required conduit modifications, including size, routing, back boxes, junction boxes, pull boxes, to achieve complete coordination with the approved security equipment and wiring diagrams provided in the shop drawing submission process.

KK. ARRANGEMENT OF WORK

1. The drawings are partially diagrammatic and indicate general arrangement of the work. Drawings may not show all work specified. Consult the balance of the project contract documents drawings and specifications for additional installation requirements, equipment and exact locations and space coordination, and coordinate installation with the work of other trades.
2. Maintain maximum headroom and accessibility for maintenance, and prepare large- scale drawings of the work where tight space conditions exist and where installation conflicts appear likely. Secure the approval of other trades and the Engineer before proceeding.
3. Refer to respective Architectural Reflected Ceiling Plans for ceiling mounted devices, and respective Architect's Interior and Exterior Elevations for wall mounted equipment.
4. Where Architectural Reflected Ceiling Plans or Interior and Exterior Elevations do not show devices or equipment lay out all wall and ceiling mounted devices on each floor in a walk-through with the Architect. Tag or suitably mark all device locations as directed by the Architect and use as location for actual, final rough in.
5. If a walk through with the Architect does not locate all devices not shown on architectural drawings, request in writing "location-sketches" of devices still not located by the Architect. If such sketches are not provided after such

written request, timely notice, and construction schedule requires rough in, mount in accordance with locations shown on Request for Information (RFI) detail drawings created by the Contractor and submitted to the Architect for clarification and approval.

6. When work calls for “homerun” connections, include all work necessary to bring wire to that location as part of the bid price.
7. For any equipment located so that maintenance or service requires removal, leave adequate cable slack for equipment maintenance and terminations in the panels. Failure to leave adequate cable slack may be cause for rejection of work and complete rewiring, without any allowance for splices or terminal blocks by the contractor.
8. Where security system cabling must be co-mingled with other system cables, the security contractor shall coordinate the cable installation and conduit sizing with the appropriate contractors.

LL. VERIFYING JOBSITE CONDITIONS

1. Before commencing work, examine all existing and adjoining work on which this work is in any way dependent for perfect workmanship according to the intent of this Specification. No “waiver of responsibility” for incomplete, inadequate or defective “existing” conditions or “adjoining” work will be considered unless notice has been filed prior to commencing work.
2. Become thoroughly familiar with actual existing conditions at the building site. The intent of the work is shown on the drawings and described hereinafter, and no consideration will be granted because of lack of familiarity on the part of the Contractor with actual physical conditions at the site.
3. Review conduit system in building, trough, cable trays, door frames/storefront construction curtain wall assemblies, and insure proper installation of wiring can occur. Review any precluding field conditions with the Construction Manager and Architect.

MM. CONFIDENTIALITY OF DOCUMENTS

1. The documents, consisting of all technical proposals, drawings, specifications, shop drawings, as built, manufacturers’ literature, etc., shall be considered proprietary information and treated with complete confidentiality. Dissemination of any security system documentation to any party without a pre-defined and approved “need-to- know” status will be considered a violation of the contract documents and all pursuant clauses regarding financial penalties, project termination and/or legal prosecution apply. Obtain a list of “need-to-know” parties from the Owner and/or Construction Manager.
2. Use of these plans and specifications is restricted to the original site for which they are prepared. Publication therefore is expressly limited to such use. Re-use, reproduction, storage by any medium or publication by any method in whole or in part is prohibited. Visual contact with these plans and specifications constitutes prima facie evidence of the acceptance of these restrictions. Unlawful publication, dissemination and use of these documents carry significant liability and the Owner maintains the right to legally pursue restitution and/or penalty for violation of these confidentiality conditions.

NN. SUBCONTRACTING OF WORK

1. Skilled personnel directly employed and supervised by the Electrical and Security System Contractors shall perform all work.
2. The Security Contractor may elect to have wiring installed by the project electrical contractor. Coordination of labor and assignment of work shall be accomplished prior to bid and a price for the complete installation provided in the bid.
3. OWNER FURNISHED AND/OR EXISTING SECURITY EQUIPMENT
4. The Owner may furnish equipment and devices for installation under this contract as indicated herein.
5. The Contractor or his representative will be required to sign an itemized equipment receipt for Owner supplied equipment. After receipt, the Contractor will then be held responsible and liable for the loss of, or damage to the equipment until the job is completed and accepted by the Owner.
6. Any Owner-furnished equipment and/or devices that are not installed for any reason shall be returned to the Owner's Representative.
7. AUTHORIZED CHANGES IN CONTRACT WORK REQUIREMENT
8. The Contractor shall note that the Contractor shall make no changes in the work requirements or scope of work under this contract without a written modification to the contract in accordance with Division 1 of the Specifications.

PART 2 PRODUCTS

A. SYSTEM COMPONENTS

1. All materials shall be strictly in accordance with the manufacturer's model numbers, performance levels, quality, style and sizes, as specified herein. Manufacturer's names and model numbers are given in the Specifications for the purposes of establishing a standard of performance, quality, style, size, and type and shall be considered to exclude equipment and materials of other manufacturers unless the words "or approved equal" appear in the Equipment Specifications Section.
2. When the Contractor is allowed and elects to substitute materials or equipment other than that specified, the Contractor will be held responsible for all structural, mechanical, and electrical changes required for their installation at no additional cost to the Owner.
3. When the Contractor receives approval to substitute, he shall include, during the Shop Drawing submission process, complete specifications of the substituted item, and shall indicate all differences from the corresponding item specified herein.
4. When a specified manufacturer's product has been superseded by a newer model, the later model shall be furnished, provided the newer model retains the essential characteristics of the item specified herein and maintains compatibility with other new and/or existing integrated systems hardware and software. Indicate in submission if such condition exists.
5. The materials and equipment to be furnished shall be new and unused and fabricated from new materials. Factory "reconditioned" or "refurbished" products will not be allowed.

6. Materials and equipment shall be, where so specified, UL labeled, as required, and shall bear the manufacturer's name, model number, and any other Listing Agency identification markings.
7. Equipment and materials of the same general type shall be of the same manufacture throughout the project to provide uniform appearance, operation, maintenance, and compatibility with existing components and/or systems.
8. Materials and equipment shall be the standard product of a manufacturer regularly engaged in the production of the required type of material or equipment for at least five (5) years (unless specifically exempted in writing by the Architect or his designee) and shall be the manufacturer's latest design with published properties.
9. This specification package reflects the range of anticipated system equipment and components to be used as part of the completed security system. The Contractor should also refer to the security system drawings to determine the extent of product/system requirements necessary. If the drawings show a product which is not called out in this specification, confirm product manufacturer and model number with Engineer prior to purchase. Submit shop drawings as if the product were listed in the project specifications.
    a. If additional equipment is required due to specific job conditions or system configuration, products and equipment shall be supplied in accordance with the required submission process to create a complete and operational system.
    b. Where special, custom designed systems are to be engineered and fabricated by the Contractor, components shall be selected by the Contractor which provides electrical performance criteria, and operational criteria identified in these specifications. Equipment selected shall be of the heavy duty commercial/industrial type, and shall be selected to provide mean time to failure and mean time to repair at values no less than that associated with the intrusion detection and access control multiplex panels, CCTV digital video multiplex/recording equipment, CCTV, and security device power supplies. This equipment is referenced to identify and set a standard for the expected quality of microelectronic circuit boards, power supplies, chargers, etc. on a system by system basis.

B. SYSTEM DESIGN INTENT

1. It is the intention of this system design to integrate the head end software of the video surveillance system and the Access Control System/Intrusion Detection System (ACS/IDS). Upon an alarm input to the Access Control System, the Access Control System software shall have the capability via TCP/IP to retrieve a predetermined associated live video feed and display that video feed on a monitor in the main Security Control Room and/or an associated ACS/IDS Computer Workstation. This shall occur automatically through software without operator input. The operator shall then have the capability to query the NVR through the Access Control System software to view recorded video of that location. The operator shall then have the capability to export video to hard drive or CD, or close the video window by acknowledging the alarm. The Access Control System TCP/IP driver shall be included with the standard version of software and must be backwards compatible with all previous versions of video surveillance head end equipment.

EQUIPMENT SPECIFICATIONS

1.1 INTRUSION DETECTION SYSTEM

A. Door Contacts

1. Wiring shall be concealed in conduit in the wall.
2. Door Contacts shall be as manufactured Sentrol 1076D or other Sentrol product as conditions require.
3. For rolling grilles, sliding doors, and shutters, use units for up to 3” gap, or ¾” to 3” gap contact-type to provide fully supervised circuit loop as manufactured by Nascom Model N200AUMM/STHS. Do not use contacts that require a floor mounted device.
4. For recess glass doors with aluminum frames, not requiring D.P.D.T. contacts, use ¾” gap. Contact type to provide fully supervised circuit loop. If D.P.D.T. contacts are required, use 3/8” gap.
5. Provide all contacts with sufficient wire lead length and stainless steel armor sheathing to allow an installation free of exposed conductors, unnecessary splices, and inappropriately placed junction boxes between contact mounting and connection to alarm signal homerun cables and their associated junction box. Note: contacts are generally manufactured with standard 1’-0” pigtails.
6. Review installation application and conduit and junction box rough-in prior to purchase and order longer pigtails, as required. See part 3 of these specifications governing door contact installation.
7. Do not surface mount contacts other than those shown on the drawings to be surface mounted without prior approval from the Architect and Engineer.
8. Color selection per door by Architect from manufacturer’s standard color range.
9. Wherever possible, Contractor shall use approved factory manufactured configuration of door contact with built-in and potted end of line resistors to eliminate field installation of resistors and to provide continuous stainless steel sheath potted into door contact switch body.
10. Electric Locks, Power Transfer Devices, Power Transfer Hinges and Fire Alarm Release Shall be furnished by the Division 8 Hardware Supplier and Division 16 Fire Alarm Contractor. Verify all voltage and current draw requirements of electrified locking hardware. Match up power supplied to electrified door locking hardware accordingly. Locks and their respective power supplies shall be wired, terminated, and tested by the Electrical and Security Contractors.
11. The Construction Manager shall coordinate division of responsibilities between Contractors and Suppliers with these specifications Division 8 “Finish Hardware,” and Division 16, “Electrical.” Review power transfer and electrified panic hardware request to exit signal conductor requirements with the hardware supplier to achieve coordinated electrical interface between the hardware and the access control system for lock power and request to exit signaling.
12. The Construction Manager shall coordinate division of responsibilities and labor and materials required to interface any ADA power operated doors, their controls, and card access system equipment. The Security Contractor shall

furnish all required supplementary relays to integrate card access control and power door operators.

13. The Fire Alarm Contractor shall provide all required control wiring, power, and relays to release doors or fail safe electric locks, as required. These shall be installed by the Electrical Contractor, under the supervision of the Security Contractor when card access is required.
14. The Hardware Supplier shall furnish all electrified locks, power supplies, and associated wiring diagrams.
15. Access Control and Alarm Point Monitoring/Control System
16. Provide all equipment as required for a completely operational system including all new and future readers, input ports, output ports, etc., as indicated in the bid documents, plus additional 20% spare for expansion.
17. The Contractor shall ensure that all hardware and software prior to the completion and acceptance of the contract shall be upgradeable and backward compatible with any previous portion of the installation.
18. The Contractor shall ensure that all hardware and software prior to the completion and acceptance of the contract is compatible with the video surveillance equipment, as outlined in PART 2 of this Specification.

B. ACS Software Configuration

1. The SMS shall automatically provide default names for all inputs, outputs, readers, and extension boards. The SMS shall allow text description of all configured objects. The SMS shall clearly display which hardware objects (inputs, outputs, readers) on a controller are configured, and which are not.
2. The SMS shall provide templates for all objects. These templates shall be operator configurable to provide default values for data fields within an object's configuration.
3. The SMS shall support an unlimited number of groups. The SMS shall allow the following objects in the system to be grouped including personnel, doors, inputs, outputs, elevators, readers, areas and events.
4. The SMS shall restrict the viewing and controlling of objects in the administration and monitoring stations via operator privileges. There shall be different levels of controls within the system for administration privileges versus monitoring privileges.
5. The SMS shall support unlimited operator accounts with unlimited definable privilege levels.
6. The SMS shall support Windows single sign-on (SSO) that integrates login credentials with operator permissions to provide seamless user authentication and authorization.
7. The SMS shall have context sensitive online help (at the screen level) available at any point requiring operator input.
8. Monitoring Operator Interface / Activity Monitoring.
9. The SMS shall contain a monitoring component that is capable of, among other things, displaying the current state of any object in the system. All text for events (alarms) in the system shall be configurable to be displayed in color based on the user specified priority of the event.

10. The SMS shall require the operator to have appropriate permissions to view and/or control any object.
11. The SMS shall support audible alarm annunciation at operator workstations (operator configurable audio (WAV) files associated with alarms).
12. The SMS shall support unlimited graphic maps and icons to be displayed on the operator workstation monitor.
13. The system shall support an operator-programmable, color graphic map display that:
14. Shall be capable of showing the floor plan and the location of alarm devices. Shall be centralized in the system configuration and displayed on the operators' workstations.

C. Clearances

1. The SMS shall support configuration of unlimited Clearances. The SMS shall support clearance activation and expiration date and time. The field controllers shall support up to 40 clearances per cardholder.

D. Custom Clearances

1. The SMS shall support up to eight (8) unique custom clearances per cardholder. The Custom clearance shall include a door or door group, a time specification and expiration date & time and/or activation date & time.

E. Anti-Passback

1. The SMS shall support timed, hard and soft anti-passback.
2. Alternate Shunt / Assisted Access Support (ADA)
3. The SMS shall support the ability to control a door for cardholders requiring assistance or an extended shunt time. The system shall support the ability to designate which cardholders require the extended shunt function. Each door shall support the configuration of a second output control relay, which may be used to control a door opening or similar device.

F. Database Partitioning

1. The SMS shall allow for the segmentation of data in the systems database such that different user groups can access only the data in their own partitions or in partitions designated as shared. The system shall also have the ability to assign any combination of partitions to a particular user, while assigning one as the "home" partition.

G. Automated Personnel Data Import

1. The SMS shall provide a means to import personnel information from an external ODBC database. The import shall execute automatically on a schedule without the need for operator intervention. The import procedure shall also perform the necessary validity checking to prevent corruption of the SMS personnel database.

H. Custom Cardholder Events

1. The system shall support a maximum of eight (8) Custom Cardholder Events per person. Within the cardholder record, the user shall be able to add custom events that are specific to that cardholder. These events shall only be

activated when the cardholder utilizes their card at designated doors/elevators.

I. Intrusion Zones

1. The SMS shall support intrusion zones, which shall be a user specified group of inputs, outputs and/or doors. The intrusion zone shall facilitate arming and disarming of a group of objects, rather than individual objects. An intrusion zone shall be in one of two (2) modes: armed mode or disarmed mode. The mode of the intrusion zone may be changed either from an event action, monitoring workstation, or locally, within the intrusion zone, by an authorized card holder.

J. Keypad Commands

1. The SMS shall support Keypad Commands that allow the user to activate events from a designated reader keypad. A Keypad command shall be a unique number that shall be entered on the keypad (with optional prompting) to activate a specific event. The command may be configured to require a card presentation and/or a PIN to validate the user. The Keypad command may be designated as valid for specific personnel group or groups as well as limited to specific doors.

K. Threat Levels

1. The SMS shall support Threat Levels. Threat Levels shall provide the system with the ability to modify access requirements at door or door group. The Threat Level shall be visible to the Monitoring Station by both label and color and shall provide the capability to enable or disable an event that can be associated to any system defined action(s) including clearance filtering.

L. Emergency roll call report

1. The SMS shall support an emergency roll call report that shall provide a listing of all personnel in a user-specified area. The emergency roll call report shall be initiated by an event or run as a manual report by a system operator.

M. Intelligent Network Controller

1. The SMS shall support an Intelligent Network Controller (INC) that shall be an independent and totally self contained, microprocessor controlled Network Controller. The INC serves as the data collection and communications interface between the System Server and the various field devices such as card readers, alarm inputs and control outputs. INCs shall be wired at any point on the Local Area Network (LAN)/Wide Area Network (WAN) via industry standard Ethernet cabling utilizing the TCP/IP protocol. The INC to System Server communication shall include authentication and a minimum of 256 bit encryption that conform to industry-accepted standards. The INC shall support DHCP and may be configured to accept IP address and device names from local DHCP (Dynamic Host Configuration Protocol), WINS (Windows Internet Naming Service) or DNS (Domain Name System) servers. Communication between the System Server and the INC shall be asynchronous. The Intelligent Network Controller shall not require any poll messages between the System Server and the INC.

N. INC Capacity

1. Each INC shall support a maximum of sixteen (16) card readers, one hundred and ninety two (192) supervised inputs and one hundred and seventy six (176) relay outputs. The General Controller Module (GCM) is the core of the Intelligent Network Controller. The GCM consists of three major subsystems, Software services, GCM Hardware and the Access Control Module (ACM).

O. Memory Configurations

1. The GCM board shall support 64MB of on-board memory for cardholder and event storage and be capable of expanding to 128MB via a field upgradeable DIMM. There shall be 16MB of on-board FLASH that shall be used for boot code and operating system code.

P. Regulatory Approvals

1. The INC shall meet the following regulatory requirements: FCC Part 15, CE, UL 294, and UL 1076.

Q. Dual Network Support

1. The INC shall also contain two Type II PCMCIA (PC Card) slots for additional types of communication including modem, Ethernet, FDDI, wireless, etc. The INC shall support an alternate communication path via the PCMCIA card providing a secondary communication path should the primary Network fail.

R. Software Update Service

1. The system shall provide the ability to update the INC firmware stored in FLASH remotely from the host or from the diagnostic service.

S. Access Control System (ACS)

1. All access control head-end equipment, including field multiplex panels, input/output control boards, card reader control boards, control software, and any other equipment needed to make a fully functional, networked access control system that is approved for seamless control and integration with the specified video surveillance equipment.

1.2 MANUFACTURERS

A. Lenel United Technologies

1. LNL 3300 Intelligent System Controller
2. Dual reader interface device: LNL 1320
3. Single reader interface device: LNL 1300
4. Sixteen point input control board: LNL 1100
5. Sixteen point output control board: LNL 1200
    a. Provide tamper switch on factory enclosure door and wire to Intrusion Detection System (IDS) as an alarm input.

B. Description

1. The Security Management System (SMS) shall be an integrated system that utilizes a single, Open Database Compliant (ODBC), relational database management system for the storage and manipulation of related data. The SMS shall utilize an embedded Progress Database. The SMS shall include a server with operating system and applications software, operator and

administrator workstations with appropriate software, hard copy printers and fixed magnetic storage media. The security devices shall communicate with the field panels via a dedicated cable network. The field panels shall communicate to the server via a Fast Ethernet 10/100, TCP/IP network.

C. Scalability

1. The SMS shall allow for growth and scalability from a low-end or entry level system to a high end or enterprise system by increasing CPU power and memory. The SMS shall be modular in nature, allowing system capacities to be easily expanded without requiring major changes to system operation. All defined system data as well as historical information shall be maintained. The SMS shall include an intuitive .NET based badging solution with a WYSIWYG badge layout editor and GUI for badge design.

D. Card and Reader Support

1. The SMS shall support configuration of unlimited card formats. The SMS shall support up to 10 card formats per card reader. The SMS shall support readers that provide Wiegand signaling and magnetic signaling to include:
   a. Wiegand swipe readers
   b. Proximity readers
   c. Biometric readers
   d. Smart card readers
   e. Wireless readers
   f. Magnetic readers
   g. Occupancy Restrictions

E. The SMS shall support counting of cardholders in a designated area and provide both minimum and maximum occupancy restrictions. The system shall also enforce buddy system access to this area, and/or enforce area-lockout.

F. Blue Tooth Card Readers Shall be:

1. LenelS2 Multi Technology Standard sized Reader with PINpad
   a. LNL-R11325-05TB.
2. LenelS2 Multi Technology Mini-Mullion Reader
   a. LNL-R11330-05TB.

G. Power Supplies for Electric Locks

1. Shall be as manufactured by Life Safety Power FPO150 / 250-2C82D8PE4M1.
   a. Includes enclosure and backplane and power supplies and (2) 12VDC batteries.
2. Provide 16 (SIXTEEN) individually fused outputs, with relay outputs to intrusion detection system to indicate loss of AC power, and low battery.
3. Provide tamper switch on factory enclosure door and wire to alarm monitoring system as ACS. Provide complete with internal battery and transformer.

1.3 VIDEO SURVEILLANCE SYSTEM

1. Axis Communications P3245 fixed dome for interior installations.
2. Axis Communications P3245E fixed dome for exterior installations.
3. Axis Communications A6055 PTZ. Confirm locations with CUPD if required.
4. Network Video Recorder and storage by Cornell University.

1.4 EMERGENCY PHONES

A. Emergency phones shall be Viking 1600A.

B. Each emergency phone shall have it's own dedicated voice circuit.

C. Each emergency phone shall be located to meet ADA requirements for height clearance and have required signage.

1.5 WIRE AND CABLE

1. All cable shall be plenum rated.
2. Low Voltage Security Alarm Signal Cable shall be twisted, single pair, shielded cable, with shield drain wire, with overall jacket, gauge calculated to compensate for length of run and current requirements. All conductors for security zone signal to be minimum #20 AWG, UL listed. One pair #20 AWG per security device zone required.
3. Shields and twisted wire are required unless prohibited by the Access Control System or Intrusion Detection System manufacturer. 20 AWG is a minimum wire size unless prohibited by the manufacturer.
4. Low Voltage Security Power, 24VDC cable shall be minimum of #18 AWG for runs up to 150,' and a minimum of #16 AWG for runs up to 300,' twisted, shielded stranded, with shield drain wire, UL listed, jacketed, pair, separate color code from any other power circuits as follows:
5. Electric Lock Power Cable shall be minimum of #14 AWG for runs up to 200' serving a single lock. Twisted, shielded, stranded, jacketed pair, UL listed, separate color ode from any other power circuits. A separate wire pair is required for each electrified locking device/lock).
6. Access Control System Card Reader Data and Power Cable shall be 7 conductor, #18 AWG UL listed, stranded with overall shield and drain wire. Note 7 conductor cable is minimum, even if reader requires less than 7 conductors.
7. Local Audible Alert Power Cable shall be minimum of #18 AWG for runs up to 100', twisted, shielded, stranded, jacketed pair, UL listed, separate color code from any other power circuits. Over 100' use #16 AWG Wire.
8. UTP cable for video and camera data line signals shall be CAT6A. Where high pair-count cables are shown on riser drawings.
9. 24 VAC Camera Power Cable shall be #16 AWG, twisted, shielded, stranded, UL listed with drain wire, Model #25294, or equivalent.
10. Network connection cables and video/data cables shall be CAT6A.

PART 3 EXECUTION

1.1 CONTRACTOR'S ENGINEERING AND DESIGN RESPONSIBILITIES

A. The contractor shall include adequate time and technical engineering expertise to refine and complete the final design aspects of the installation to reflect the specific requirements of each piece of equipment and subsystem to be utilized as part of the system installation.

B. As a result of the contractor's engineering and system integration design, if it is determined that additional equipment is required beyond that shown on the drawings or called for in the specifications, such shall be provided at no additional cost. It is not the owner's or engineers' intent to require the contractor to increase the quantity of detection, reporting, surveillance, communication or access control applications, but rather to insure that variances in manufacturer's products, substitution of equipment, superseding of equipment by manufacturer's distributors or the system integrator, or custom design of special system components are not responsible for the system's equipment shown from working in a manner that does not fully utilize their published performance criteria. If additional or larger power supplies, relays, zone expander modules, software, line drivers, amplifiers, hubs, modems or other support components are required, they shall be provided as part of the integrator's installation.

C. The final required arrangement of conduit and cable sizing and type and routing will be dependent on the approved equipment selected as part of the shop drawing submission process. The Security Contractor is hereby cautioned and instructed to install wire, in point to point and homerun routing and sizing in accordance with the approved conduit, cable tray and wiring drawings submitted jointly by the Electrical and Security Contractors. The selection of outlet boxes, extension rings and cover plates for device mounting shall be installed per these same criteria.

D. The Contractor is required to read the Specifications covering all aspects of the work and will be held responsible for coordination of his work with work performed under all other contracts.

E. Building security and access control system shall comply with the rules and regulations of the local Building Code, and as required for all government approvals.

F. All systems are to be factory engineered to provide the functions described herein and as provided by the capabilities of the products specified in Part 2.00 of these Specifications.

G. Calculations and drawings shall be furnished by the Contractor for this system which shall meet the requirements of approving and listing agencies, the Architect or his designee.

H. The Security System Contractor shall include in his Bid the cost for factory engineering and field tests to verify design calculations and system performance as required for approvals.

I. If the Contractor has any questions concerning the Plans and Specifications, he is to contact the Architect in writing, for clarification prior to bid, to fully understand the extent and responsibilities of his work.

J. The Contractor's security system design submission shall be based on calculations which provide for the proper functioning of all devices shown on the drawings and functions, as specified herein, and as required to integrate with the Access Control System front-end, located in the Security Control Room.

K. The Security System Contractor is responsible for locating all ceiling mounted detection devices in all suspended or other type ceilings, in accordance with Architectural Reflected Ceiling Plans. This Contractor shall also refer to Architectural Reflected Ceiling Plans for locations of other trade items in ceiling systems where shown. As above, for wall mounted equipment, refer to Architectural Interior and Exterior Elevations.

L. In some special cases, devices occur in hung or suspended ceilings with lay-in or limited access spline ceilings, and are not to be located in the tile centers, but in accordance with an alignment of other trade items which define an imaginary architectural grid line. Refer to the Architectural Drawings for locations of tile centering or grid alignment.

1.2 CONDUIT AND WIRING

A. All necessary and incidental wiring associated with the Security System shall be furnished as part of this contract.

B. Wiring to provide all 120 VAC sources and points of connection to same shall be furnished and installed by the Electrical Contractor.

C. All cable shall be plenum rated.

D. Special device back boxes, unique to security products, shall be furnished by the security contractor.

E. All conduit is provide by the Electrical Contractor.

F. All wiring shall be installed in conduit. Wiring and conduit installation shall be in accordance with the latest edition of the National Electrical Code, with conduit fill requirements as though system wiring were 120VAC, (40% conduit fill) and the requirements of Division 26, Electrical Specifications. Up-size conduits from sizes shown on drawings, as necessary not to exceed 40% fill criteria. All conduit shall be ¾" minimum unless otherwise noted on the floor plans, riser diagrams or device installation details. Do not exceed 270° of bends in any EMT run without a pull or junction box.

G. Insure cabling shield does not touch terminal connections. Provide "one-end" ground on all shields using drain wires at control panels, power supplies, or head end equipment, then to separate and dedicated RF ground via #8 AWG copper cable. Insulate shield at device end with shrink tubing to completely cover shield and drain wire. Where multiple devices are served by the same shielded cable, shield continuity shall be maintained and properly insulated to eliminate intermittent grounding. Do not bring shield grounds to a building electrical ground. Carefully follow manufacturer's instructions and advise Engineer accordingly. Shield grounds shall be treated as specified herein unless prohibited by manufacturers.

H. Lay out conduit and cable runs with Electrical and General Contractor prior to installation, and maintain 1'-0" clearance from parallel runs with 120VAC or larger

voltage conduit and wiring. Cross 120VAC or larger voltage conduit runs at 90° to reduce EMI and RF induction in security wiring.

I. All wires shall be color coded to provide separate identification of intrusion alarm signal, 12 VDC, 24 VAC, card access, lock power, video signal, CCTV alarm input, zone expansion or relay board power and databus or any other system function. Wires shall be similarly coded for each system serviced throughout the entire installation.

J. All resistors shall be solder connected to eliminate any additional circuit resistance. Stranded wires connected to resistors shall be solder-tinned to insure positive solder connection. Resistors shall be insulated with shrink tubing extending a minimum of 1” either side of resistor. (Unless factory installed and potted as part of magnetic contact construction.)

K. No intermediate cable splices are allowed without the specific written approval of the Engineer. Request clarification and approval prior to installation of any splices.

L. All alarm circuits shall be tagged at the device end and field multiplex control panel end with alarm panel or zone addressing module hardware circuit terminal address numbers.

M. Transformers and power supplies shall be identified, along with their cable, at both transformer and load fed end of cable.

N. Each card reader access control system cable shall be tagged at both the device and access control field multiplex panel end with the door opening number and device type (i.e. card reader/keypad, electric lock , etc.).

O. All video surveillance cabling shall be labeled with tags at the camera and control end with corresponding numbers. Patch cords between equipment shall be labeled, wherever possible, with field equipment label designations, to create as uniform a tagging system as possible.

P. All 24VDC power circuits shall be tagged at each device and 24VAC power supply fused terminal strip with 24VAC panel and fused circuit number.

Q. All power cables shall be tagged at the device end and power panel end with matching numbers.

R. All wiring in panels shall be neatly dressed, run parallel wherever possible, and provided with adequate slack for future maintenance and service terminations.

S. All “unused” wire conductors shall be capped to eliminate shorts and grounds, tagged with their terminal points and identified as “spare” at each end with a unique spare cable tag identification system.

T. Minor deviations (relocations) in wire runs to installed mounting locations may be required prior to final acceptance when site conditions affect the equipment’s operation, performance, or purpose. Relocations which require only minimal work (plus or minus 15’) and/or materials shall be made without additional cost or credit.

U. The Contractor shall note that connection of alarm zone circuits to the intrusion detection panels and field multiplex panels will require the installation of end-of-line resistors in each zone circuit. Locate as close to the device as possible to provide

as much circuit supervision as possible. EOL resistors shall not be located at the panel for active security circuits, unless full line supervision is provided by a 4 wire circuit. All unused zones shall have the end-of-line resistor mounted in the panel if manufacturers' requirements so dictate. Where end-of-line resistors are to be mounted at devices that are factory sealed and have factory configured wire leads, the resistor shall be spliced in-line with the leads as close to the device as possible (splices shall be soldered and covered with heat shrink tubing as specified elsewhere in these specifications).

V. The Contractor shall install panel cover-operated tamper switches in each equipment enclosure, cabinet, and/or housing, to actuate an alarm signal before access to equipment wiring within the enclosure is gained. Tamper switch mounting hardware shall be concealed so that the location of the switch cannot be visually detected from the exterior of the enclosure. These circuits shall be supervised. Multiple panels, of the same subsystem type, may be wired as a common security zone.

W. All wiring or cable shall be tested for, and be free of, opens and shorts. All wiring shall test free of grounds with the exception of circuits that are intended to be connected to the ground side of protective circuits.

X. All wire and cables entering equipment cabinets and enclosures shall be grouped and tied inside the enclosures on 6-inch centers with self-locking nylon cable ties. All wiring shall be grouped in an orderly fashion. Under no circumstances is the use of adhesive tapes (electrical or other) permitted for either permanent or temporary ties or wire management.

Y. All stranded wiring that is connected to equipment that has terminal strips or screw lugs shall be terminated with either nylon insulated crimp-on spade lugs, equal to Thomas & Betts STA-KON fork tongue locking type or equivalent, sized for correct wire and screw sizes or shall be solid bare wire attached to screw terminals. Where compression screws are used to cap stranded wiring, wiring shall be tinned to eliminate destranding and consequent poor connection. Each wire shall be documented on the as-built wiring diagrams.

Z. All wiring that is connected to equipment with solder lug connectors shall terminate wire to lug in a solder joint. The solder joint, lug and any bare wire shall be covered with heat shrink tubing. Multi-conductor bare wire ends shall be soldered to prevent de-stranding.

AA. Each wire and cable shall be clearly marked within each enclosure, junction box, or where termination is made. Wires and cables shall be marked with a clear, heat-shrink system such as "Shrink Mark" or equivalent, labeling system as manufactured by RayChem. Cable numbers shall be generated on a PC. Felt-tip "Sharpie" type pen markings are unacceptable. Marking documentation shall be included with the detailed wiring diagram to be provided to the Owner on completion of the installation as part of the As-Built documentation in the "Project Manuals".

BB. Wiring and cables that are installed shall maintain color coding from origination point to termination point. Where paired cable is used, the pairs in the cable shall be maintained in the run. Pairs shall not be separated to form different pairs than those in the original cable. Color coding shall be maintained within the system. Maintaining color coding applies to all type circuits in the system.

CC. Review wiring type, scheme and tagging for all systems prior to installation, with factory/technical representatives. Advise the engineer of any required modifications prior to wire procurement and installation and obtain approval accordingly. It is the contractor's responsibility to review the system's wiring with the factory representatives and supply the cables which meet their requirements. Where heavier gauge cables are specified by the engineer and such provide enhanced performance reliability, durability or future capacity, they shall be used unless prohibited by the manufacturer. Where cable gauges must be increased, due to length of runs in the field, they shall be provided at no extra cost to the Owner.

DD. For the CAT6 video pairs and pan, tilt, zoom data pairs, the same color pairs shall be throughout the system. One color pair shall be chosen for all video signals and two color pairs shall be chosen for all data signals.

EE. Paralleling of multi-conductor cables to "create" a cable of larger wire gauge is prohibited, except at door frame power transfer hinges or knuckles.

FF. Wiring diagrams shall be provided in all signal and power panels along with cable schedules, in a clear plastic envelope, for future use in system maintenance and service.

GG. Run electric lock power circuits so that each electrified locking door opening is wired on its own, to a dedicated fused circuit in a dedicated lock power supply.

HH. Connect no more than five (5) 24VDC security or Rex Devices to a single 24VDC power circuit on a dedicated fused outlet in the 24VDC power supply. Land no more than two pair #18 on each fused terminal screw port. Use terminal strips to collect individual 24VDC power circuits to devices and cross-connect to power supply fused outlet terminal screws.

II. Security equipment panels, located at SDFs shall be interconnected using EMT. Panel connections to SDF conduit trough shall be in EMT. Conduit stubs shall be extended to above ceiling areas using EMT to connect cable to field devices, as shown on the SDF details, floorplan drawings and riser diagrams. Add additional EMT, as required, to assist in wire pulling.

JJ. Tamper wire equipment trough. Connect on same zone as IDS field multiplex panels. JJ. Maintain a minimum of 6' clearance from variable speed drives, transformers, 480V and higher electrical service, and other known sources of RF and EMI. Maintain 2' clearance from florescent ballasts.

1.3 LICENSING/COMPETENCY

A. This Contractor shall be a bona fide security systems contractor, licensed by the State of New York for the installation of the low voltage security and signal communication systems, and engaged in security system maintenance, service and contracting for at least the last ten years.

B. The Contractor shall employ technicians who have been trained by the factory to install the systems of their manufacture.

C. The Contractor shall be, or shall hire, a factory authorized stocking distributor of the manufacturer of the equipment included in the system so that immediate

replacement parts can be made from inventory and service provided as needed on an emergency basis.

1.4 FACTORY SUPPORT

A. A full service contract, providing all parts and field labor on equipment shall be available, local (60 miles) to the site with labor to be provided by factory trained, system technicians. Manufacturer shall have available an existing, regularly scheduled formal factory training program for Owner's technicians.

B. The successful Bidder shall engage the services of the local Factory Customer Service Technician to perform or supervise the final hook-up, integration and check-out of the System, and to insure validation of the Warranty of system components at the site.

C. The Contractor shall include in the Bid Cost, one complete factory training session, as called out in these specifications to support the Owner's system users in system's operation, database creation, and all other aspects of intended user interface.

1.5 MANUALS

A. Contractor shall carefully complete, during progress of work, operation and maintenance manuals to include methods of care and cleaning of all types of visible surface materials both interior and exterior, and descriptions of all systems and equipment and methods of operation thereof. Descriptions shall give pertinent diagrams, identifying charts, color coding, connections, maintenance instructions, programming sequences and constraints, programming values, data base development routines, loaded database file information/ data, and single-line and detailed wiring diagrams.

B. Use manufacturer's printed information where possible, otherwise obtain written instructions prepared by the installer. Include names, addresses and telephone numbers of all service firms for each item, for the Owner's use after expiration of guarantee period.

C. Contractor shall provide manuals describing in detail the operations of all components of system. Such manual shall be adequate in detail to serve as an operator's handbook to guide and instruct operators in all set-up, programming, and database entry, automatic and manual operations of equipment.

D. These manuals shall contain full support documentation, which shall include, without being limited to the following:

E. General description and specifications

F. Installation and initial checkout procedures, available to the Owner's staff

G. Principles and theory of operation

H. Detailed electrical and logical description

I. Complete trouble-shooting procedures, diagrams, and guidelines within User's capabilities

J. Complete alignment and calibration procedures for all components

K. Preventative maintenance requirements

L. Detailed schematics and assembly drawings

M. Complete spare parts list

N. Interface requirements and capabilities

O. Signal identification and timing diagrams and settings

P. User database development instruction and forms

Q. Programming options and requirements

R. General Operational: This document shall describe, in laymen, non-engineering terms, all the functional and sequence of operational requirements for the system and its functions that have been established. It shall not require extensive knowledge of electrical engineering techniques or control system theory, or security engineering.

S. System Operation: Complete guidance and procedures for operation of the system, including required actions at each operator position, and emergency, alarm, and failure recovery procedures. Step-by-step instructions for system activation and reset, backup equipment operation, and execution of all system functions and operating modes shall be provided.

T. An operations matrix shall be provided in which all intrusion detection and access control alarm inputs, and associated relay outputs and other exceptional condition functions are related to all other interfaced sub-system events, including CCTV assessment and recording system, so that each system event can be logically linked to activation of another system using “if/then” logic in chart form. Matrix shall address field related events, operator initiated events and time-zone events.

U. Functional Description: Detailed documentation, in language readily understandable to systems maintenance personnel, the theory of operation, design philosophy, and specific functions of the system. Full details of detection loop components and interfaces, and operator test or self-test of detector/initiating integrity for all system components and peripherals during each system function and operating mode shall be provided. Hardware functions, system component interfaces, and requirements shall be explicitly detailed for all system components in all system functions and operating modes.

V. Person-equipment interactions shall be functionally described as required to supplement data called for in the preceding paragraph in providing a complete system description. Known or established constraints on system operation shall be fully described. Any operating procedures currently implemented or planned for implementation in an automatic or manual mode shall be stated and described.

W. Maintenance: Documentation of all user-performed maintenance on all system components including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective units. This shall include calibration, maintenance, and repair of all components and controls, plus diagnosis and repair

or replacement of all system hardware, and software, not part of the Installer's standard service contracts.

X. Contractor shall complete as-built documentation manuals to include descriptions of all conduit, trough, and of any other raceway systems, complete cable installation and all security equipment and methods of installation.

Y. A special documentation Section shall outline all drag-line and box labeling to assist in the installation of any future equipment by a security contractor.

Z. Contractor shall provide manuals describing in detail the operations of all components of all systems. Such manuals shall be adequate in detail to serve as an operator's handbook to guide and instruct operators in all automatic and manual operations of equipment, and to provide adequate detail to allow basic system maintenance diagnostics and testing so that only essential service call back by the Installer is required. They shall include all programming values, access codes, alarm transmission formats, default codes, output relay trip programming and system database loading of all on-site programmable equipment. These manuals shall be assembled and written specifically for this job. Include these manuals as a part of the final turnover.

AA. Include names, addresses and telephone numbers of all component manufacturers or dealers, and of service firms for each item, for Owner's use after expiration of guarantee period.

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Section 28 05 13

CONDUCTORS AND CABLES FOR FIRE ALARM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Coaxial cabling.
   2. Fire alarm wire and cable.
   3. Fire alarm single mode, 8.2 micrometer, optical fiber cabling.
   4. Identification products.

1.2 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. EMI: Electromagnetic interference.

C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

D. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

E. RCDD: Registered Communications Distribution Designer.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. For coaxial cable, include the following installation data for each type used:

      a. Nominal OD.
      b. Minimum bending radius.
      c. Maximum pulling tension.
   2. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
   3. Cabling administration drawings and printouts.
   4. Wiring diagrams to show typical wiring schematics including the following:
      a. Cross-connects.
      b. Patch panels.
      c. Patch cords.
   5. Cross-connects and patch panels. Detail mounting assemblies and show elevations and physical relationship between the installed components.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Certified Fiber Optic Technician, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: An NRTL.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

E. Grounding: Comply with ANSI-J-STD-607-A.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
1. Test each pair of UTP cable for open and short circuits.
2. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight.

1.7 FIELD CONDITIONS

A. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.

1. Indications that wire and cables are wet or moisture damaged include, but are not limited to, discoloration and sagging of factory packing materials.

B. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.8 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 450 or less.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 OPTICAL FIBER CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Belden Inc.
2. CommScope, Inc.
3. Corning Incorporated; Corning Cable Systems.
4. General Cable Technologies Corporation.

B. Description: Single-mode, nominal 9/125-micrometer, 6-fiber, nonconductive, tight buffer, optical fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA/EIA-568-B.3 for performance specifications.

a. General Purpose, Nonconductive: Type OFN or OFNG.
b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
c. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
d. General Purpose, Conductive: Type OFC or OFCG.
e. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
f. Riser Rated, Conductive: Type OFCR, complying with UL 1666.

3. Conductive cable shall be aluminum armored type.

4. Maximum Attenuation: 8 dB at 1310 nm and 1550 nm end to end with all patch cables installed.
5. Minimum Modal Bandwidth: 500 MHz-km at 1300 nm.

C. Jacket:

1. Jacket Color: Yellow or red.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.3 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ADC.
2. American Technology Systems Industries, Inc.
3. Belden Inc.
4. Berk-Tek; a Nexans company.
5. Corning Incorporated; Corning Cable Systems.
6. CSI Technologies Inc.
7. Dynacom Inc.
8. Hubbell Incorporated; Hubbell Premise Wiring.
9. Molex Premise Networks; a division of Molex, Inc.
10. Siemon.

B. Cable Connecting Hardware: Meet the Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.

1. Quick-connect, simplex and duplex, Type ST or Type LC connectors as required to match equipment. Insertion loss not more than 0.75 dB.

2.4 COAXIAL CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Alpha Wire Company.
2. Belden Inc.
3. Coleman Cable, Inc.
4. CommScope, Inc.
5. Draka Cableteq USA.

B. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.

C. RG-11/U: NFPA 70, Type CATV.

1. No. 14 AWG, solid, copper-covered steel conductor.
2. Gas-injected, foam-PE insulation.
3. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
4. Jacketed with sunlight-resistant, black PVC or PE.
5. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.

D. RG59/U: NFPA 70, Type CATVR.

1. No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
2. Gas-injected, foam-PE insulation.
3. Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
4. Color-coded PVC jacket.

E. RG-6/U: NFPA 70, Type CATV or CM.

1. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
2. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
3. Jacketed with black PVC or PE.
4. Suitable for indoor installations.

F. RG59/U: NFPA 70, Type CATV.

1. No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
2. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
3. PVC jacket.

2.5 COAXIAL CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Emerson Network Power Connectivity Solutions; AIM Electronics Brand.
2. Leviton Commercial Networks Division.
3. Siemon.

B. Coaxial-Cable Connectors: Type BNC, 75 ohms.

2.6 FIRE ALARM WIRE AND CABLE

Basis-of-Design Product: Subject to compliance with requirements, provide products by the following or approved equivalent:

1. Comtran Corporation.
2. Draka Cableteq USA.
3. Genesis Cable Products; Honeywell International, Inc
4. Rockbestos-Suprenant Cable Corp.
5. West Penn Wire.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760. All wiring shall be in accordance with the manufacturer's preferred recommendations. All wiring shall be solid copper conductors.

C. Signaling Line Circuits: No. 16 AWG as recommended by system manufacturer.

D. Notification Appliance Circuits: No. 16 AWG as recommended by system manufacturer.

E. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.

1. Low-Voltage Circuits: No. 16 AWG, minimum.
2. Line-Voltage Circuits: No. 12 AWG, minimum.

2.7 IDENTIFICATION PRODUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Brady Worldwide, Inc.
2. Hellermann Tyton North America.
3. Kroy LLC.
4. Panduit Corp.

B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Comply with requirements in Section 260553 "Identification for Electrical Systems."

D. All labels shall be type written and laser printed.

E. All fire alarm devices and appliances shall be labeled with P touch labels with their respective address.

F. All cables will be labeled with the circuit number at all terminations and junction boxes.

2.8 SOURCE QUALITY CONTROL

A. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for installation of supports for cables.

3.2 WIRING METHOD

A. Install wiring in metal pathways and wireways.

1. All cabling including fiber optic cable shall be installed in EMT unless otherwise indicated. Minimum conduit size shall be 3/4 inch. Control and data transmission wiring shall not share conduit with other building wiring systems. ½ inch conduit shall be permitted where wiring serves only a single device or appliance.
2. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems"

B. Install cable, concealed in accessible ceilings, walls, and floors when possible.

C. Wiring within Enclosures:

1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
2. Install lacing bars and distribution spools.
3. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer.
4. Install conductors parallel with or at right angles to sides and back of enclosure.
5. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks.
6. Mark each terminal according to system's wiring diagrams.
7. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.

C. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

D. Optical Fiber Cable Installation:

1. Comply with TIA/EIA-568-B.3.
2. Cable may be terminated on connecting hardware that is rack or cabinet mounted. Fusion splices shall be completed to factory terminated assemblies.

E. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 FIRE ALARM WIRING INSTALLATION

A. Comply with NECA 1 and NFPA 72.

B. Wiring Method: Install wiring in metal raceway according to Section 260533 "Raceways and Boxes for Electrical Systems."
    1. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.

C. Wiring Method:

    1. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.

D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

F. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Color coding of wire shall be per the Owner’s Color Coding Schedule. Use one color-code .for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red. All conduit fittings shall be red. Confirm color code with the campus prior to commencing.

G. Risers: Install at least two vertical cable risers to serve the fire alarm system.

3.5 POWER AND CONTROL-CIRCUIT CONDUCTORS

A. 120-V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.

B. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No. 14 AWG.
2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.6 CONNECTIONS

A. Comply with requirements in Section 283100 "Fire-Alarm System" for connecting, terminating, and identifying wires and cables.

3.7 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-B, "Firestopping" Annex A.

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.8 GROUNDING

A. For low-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.9 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.10 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

2. Coaxial Cable Tests: Comply with requirements in Section 274133 "Master Antenna Television System."

B. Tests and Inspections:

1. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

3. Optical Fiber Cable Tests:

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
        2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

C. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

End of Section

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Section 28 46 21.11

ADDRESSABLE FIRE-ALARM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Addressable fire-alarm system.
2. Fire-alarm control unit (FACU).
3. Manual fire-alarm boxes.
4. System smoke detectors.
5. Duct smoke detectors.
6. Carbon monoxide detectors.
7. Heat detectors.
8. Fire-alarm notification appliances.
9. Emergency responder radio coverage system.
10. Fire-alarm remote annunciators.
11. Fire-alarm addressable interface devices.
12. Addressable device labels.
13. Digitize Mux Pad.

B. Related Requirements:

1. Section 087100 "Door Hardware" for magnetic door holders that release in response to fire-alarm outputs.
2. Section 280513 "Conductors and Cables for Electronic Safety and Security" for cables and conductors for fire-alarm systems.

1.3 DEFINITIONS

A. DACT: Digital alarm communicator transmitter.

B. EMT: Electrical metallic tubing.

C. FACU: Fire-alarm control unit.

D. High-Performance Building: A building that integrates and optimizes on a life-cycle basis all major high-performance attributes, including energy conservation, environment,

safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.

E. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the 2007 Energy Independence and Security Act (EISA).

F. NICET: National Institute for Certification in Engineering Technologies.

G. PC: Personal computer.

H. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:

1. Control Voltage: Listed and labeled for use in remote-control, signaling, and power-limited circuits supplied by a Class 2 or Class 3 power supply having rated output not greater than 150 V and 5 A, allowing use of alternate wiring methods complying with NFPA 70, Article 725.
2. Low Voltage: Listed and labeled for use in circuits supplied by a Class 1 or other power supply having rated output not greater than 1000 V, requiring use of wiring methods complying with NFPA 70, Article 300, Part I.

1.4 ACTION SUBMITTALS

A. Approved Permit Submittal: Submittals must be approved by authorities having jurisdiction prior to submitting them to Architect.

B. Permit Application Submittal: Submittals must be approved by the Owner and Engineer prior to submitting them to the authorities having jurisdiction.
1. Submittals are coordinated through the Owner’s assigned liaison (for example - EHS/CU FP Engineers).

C. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

D. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in "Documentation" section of "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, and details, including details of attachments to other Work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Annunciator panel details as required by authorities having jurisdiction.
5. Detail assembly and support requirements.
6. Provide floor plans in
   a. Show graphic scale and compass direction for orientation.

b. Show indication of floor or level.
c. Show all walls, doors, and partitions extending within 10 percent of the ceiling height.

7. Provide riser diagrams that are coordinated with the floor plans.
   a. Show general arrangement of the system in building cross section.
   b. Show type and quantity of conductors and conduit for each circuit.
   c. Show each riser indicating the circuit type and number.
   d. Show type and number of system components/devices on each circuit, on each floor or level.
   e. Show all devices and appliances located on the plan drawings along with all circuits.
   f. Show the address for each addressable device or appliance located on the plan drawings.
8. Provide control unit diagrams
9. Include input/output matrix.
10. Include written statement from manufacturer that equipment and components have been tested as a system and comply with requirements in this Section and in NFPA 72.
11. Include performance parameters and installation details for each detector.
12. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
13. Provide program report showing that air-sampling detector pipe layout balances pneumatically within airflow range of air-sampling detector.
14. Provide control wiring diagrams for fire-alarm interface to HVAC; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring and equipment required for HVAC unit shutdown on alarm.
    c. Locate detectors in accordance with manufacturer's written instructions.
    d. Show air-sampling detector pipe routing.

15. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
16. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

E. Primary Power Supply Calculations: For fire-alarm system.

1. Include signaling line circuit cards that all possible addresses are used.
2. Include all notification appliances are loaded to their maximum RMS current rating per designated strobe and/or speaker setting for each notification appliance
3. Include an additional 25% increase in total spare load.
4. Show each individual circuit card, including its 20% increase in total spare load per circuit, is not loaded beyond 90% of its capacity.
5. Show the total load, including spare load, for each power supply is 90% or less of its full load capacity.

F. Secondary Power Supply Calculations: For fire-alarm system.

1. Comply with manufacturer’s written instructions.
2. Include signaling line circuit cards that all possible addresses are used.

3. Include a capacity for 24-hours standby operation plus 15 minutes for full building alarm.
4. Include a 25% increase in loads per circuit.
5. Show calculations indicate the battery capacity is 50% above the combined standby and alarm value.
6. Show the ability to operate visible notification appliances (strobes, speakers and speaker/strobes) with the required voltage for the required time-period.
7. Include a complete list of the current requirements during normal, supervisory, trouble and alarm conditions for each component of the system.
8. Provide the minimum battery for all other fire alarm components shall be a minimum of the maximum battery size that can be accommodated within the cabinet.

G. Voltage Drop Calculations: For fire-alarm system.

1. Comply with manufacturer's written instructions.
2. Provide calculations using the lump sum method.
   a. Show all appliances at the end of the circuit.
3. Include calculations for each individual notification appliance circuit.
4. Include the entire circuit length for Class A and X circuits.
5. Include a starting voltage of the cut out voltage of the equipment.
   a. Show the starting voltage is less than or equal to 20.4 VDC.
6. Include the maximum RMS current rating per the strobe setting that is indicated for each notification appliance.
7. Include an additional 25% increase in total load and wire length (in accordance with the Primary Power Supply Calculations, the total load including the 25% increase shall not exceed 90% of the total power supply capacity and individual circuit card capacity). Spare capacity shall be maintained until system accepted. Where multiple circuits are installed on a floor, the load on each circuit shall be distributed within 20% of the average of all circuits.
8. Include the maximum allowed cable lengths and resistance for each circuit including all increases.
9. Show the total voltage drop is within the limits of the equipment.
10. Show circuit reference number as indicated on the plan drawings, wire distance, wire size, resistance, minimum voltage per circuit, current requirements per circuit and percent of load capacity.

H. Voice Amplifier Calculations: For fire-alarm system.

1. Include all speakers are driven at their required sound output plus an additional 25% increase in total load and wire length.
2. Include the entire circuit length for Class A and X circuits.
3. Show the total losses for each individual circuit is no more than 0.5 dBA with all devices assumed at the end of the circuit.
4. Show calculations to demonstrate that the total load (including the spare load increase) for each amplifier is 90% or less of its total capacity. Provide calculations to demonstrate that the total load for each circuit (including the spare load increase) is 90% or less of its total capacity.
5. Calculations shall include expected losses and the calculated maximum allowed cable length.
6. Show circuit reference number as indicated on the plan drawings, wire distance, wire size, resistance, minimum voltage per circuit, current requirements per circuit and percent of load capacity.

I. Shop Drawings: For Emergency Responder Radio Coverage System

1. Provide riser diagram for emergency responder radio communications system.
   a. Show cable type, size, antenna locations, grounding configurations and other details pertinent to the installation.
2. Provide scaled floor plans with heat maps, equipment (annunciator(s), all antennas, amplifiers, etc.) locations, and initial grid and final grid layout readings.
3. Include battery calculations, FCC license information, point-to-point diagram showing all terminal connections at devices and panel(s).

J. Delegated Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by qualified professional engineer responsible for their preparation.

1. Drawings showing location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of device.
2. Design Calculations: Calculate requirements for selecting spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.5 INFORMATIONAL SUBMITTALS

A. Certificates:

1. Seismic Performance Certificates: For FACU, accessories, and components, from manufacturer. Include the following information:

   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.

B. Field quality-control reports.

C. Qualification Statements: For Installer.

D. Sample Warranty: Submittal must include line item pricing for replacement parts and labor.

E. Points List: A complete list of device addresses and their corresponding descriptor. The points list shall be provided in Microsoft Excel format. The points list shall be provided to the Engineer and Owner for review prior to release to the fire alarm vendor and again at least four weeks prior to beginning the acceptance testing of the fire alarm system. The contractor shall be responsible for completing all modifications to the fire alarm system program. The descriptions shall be updated if necessary, during the testing process.

1. Waterflow switches shall be labeled to indicate the area or portion of the building that the flow switch is serving.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

a. Comply with "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire-Alarm and Emergency Communications System Record of Completion Documents" in accordance with "Completion Documents" Article in "Documentation" section of "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between devices and equipment. Each conductor must be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
g. Record copy of site-specific software.
h. Provide "Inspection and Testing Form" in accordance with "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

i. Manufacturer's required maintenance related to system warranty requirements.
j. Abbreviated operating instructions for mounting at FACU and each annunciator unit.

B. Record Documents: For fire-alarm systems and components to include in record documents.
1. In addition to items specified in Section 017839 "Project Record Documents," include the following and deliver copies to authorities having jurisdiction:
a. Provided one additional complete set of the record drawings and place in the document storage cabinet.
b. The Contractor shall update the product data for all equipment installed.
c. The Contractor shall update the shop drawings to reflect the actual installed condition.
d. The Contractor shall coordinate with the Engineer and have the engineer of record review all changes to the input/output matrix of operation that describes the sequence of operation. The input/output matrix of operation

that describes the sequence of operation is to reflect the programmed logic of the fire alarm system.

e. The Contractor shall update the sequence of operations along with the as-built drawings during the construction process. A draft, pencil-set of as-built documents and matrices shall be maintained on the job site and updated on a 48 hour basis.

C. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media and approved online or cloud solution.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 2 percent of amount installed, but no fewer than one unit.
2. Smoke Detectors, Fire Detectors: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
3. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
4. Manual Fire-Alarm Boxes: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Fire-Alarm Addressable Interface Devices: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
6. Keys and Tools: One extra set for access to locked or tamper proofed components.
7. Audible and Visual Notification Appliances: Quantity equal to two percent of amount of each type installed, but no fewer than one units of each type.
8. Fuses: Two of each type installed in system. Provide in box or cabinet with compartments marked with fuse types and sizes.

1.8 QUALITY ASSURANCE

A. Designer Qualifications:

1. Personnel must be trained and certified by manufacturer for design of units required for this Project.
2. Design must be by personnel certified by NICET as fire-alarm Level IV technician.
3. Licensed or certified by authorities having jurisdiction.

B. Installer Qualifications:

1. Personnel must be trained and certified by manufacturer for installation of units required for this Project.

2. Installation must be by personnel certified by NICET as fire-alarm Level IV technician.
3. Obtain certification by NRTL in accordance with NFPA 72.
4. Licensed or certified by authorities having jurisdiction.

1.9 FIELD CONDITIONS

A. Seismic Conditions: Unless otherwise indicated on Contract Documents, specified Work in this Section must withstand the seismic hazard design loads determined in accordance with ASCE/SEI 7 for installed elevation above or below grade.

1. The term "withstand" means "unit must remain in place without separation of parts from unit when subjected to specified seismic design loads."

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail because of defects in materials or workmanship within specified warranty period.

1. Warranty Period: Five year from date of Substantial Completion.

B. Nuisance Alarms: A nuisance alarm is considered an alarm caused by mechanical failure, malfunction, improper installation, or any alarm activated by a cause that cannot be determined.

1. If the during the warranty period, the Owner experiences more than one nuisance alarm for each 50 input devices connected to the fire alarm system or a single device as a source of two or more nuisance alarms within a continuous six month period, the Contractor shall be responsible for providing the necessary labor, materials, and technical support to correct the problem.

C. Emergency Responder Radio Coverage System

1. Contractor shall provide a 1 year maintenance agreement. This shall minimally include 2 site visits per year, an annual signal strength test and emergency service. The Contractor shall be on site to initiate the repair within 8 hours, 24 hours a day, seven days a week including all holidays.
2. In building coverage test as described in the New York State Building Code, International Fire Code and NFPA 72 shall be performed.
3. Signal boosters shall be tested to ensure that the gain is the same as it was upon initial installation and acceptance.
4. Backup batteries and power supplies shall be tested under load of a period of one hour to verify that they will properly operate during an actual power outage. If within the 1-hour test period the battery exhibits symptoms of failure, the test shall be extended for additional 1-hour periods until the integrity of the battery can be determined.
5. All other active components shall be checked to verify operation within the manufacturer’s specifications.

6. At the conclusion of the testing, a report, which shall verify compliance with the New York State Building Code, International Fire Code and NFPA 72, shall be submitted to the owner and fire code official.

PART 2 - PRODUCTS

2.1 ADDRESSABLE FIRE-ALARM SYSTEM

A. Description:

1. Gamewell FCI noncoded, UL-certified and FM Global placards addressable system, with multiplexed signal transmission and voice-and-strobe notification for evacuation.

B. Performance Criteria:

1. Regulatory Requirements:

a. Fire-Alarm Components, Devices, and Accessories: Listed and labeled by a NRTL in accordance with NFPA 70 for use with selected fire-alarm system and marked for intended location and application.

2. General Characteristics:

a. Automatic sensitivity control of certain smoke detectors.
b. Fire-alarm signal initiation must be by one or more of the following devices:

1) Manual stations.
2) Heat detectors.
3) Non-dorm room Smoke detectors.
4) Automatic sprinkler system water flow.
5) Fire standpipe system.
6) Dry system pressure flow switch.

c. Fire-alarm signal must initiate the following actions:

1) Continuously operate alarm notification appliances, including voice evacuation notices.
2) Identify alarm and specific initiating device at FACU and remote annunciators.
3) Unlock electric door locks in designated egress paths.
4) Release fire and smoke doors held open by magnetic door holders.
5) Activate voice/alarm communication system.
6) Recall elevators to primary or alternate recall floors when the associated smoke detectors actuate.
7) Activate emergency lighting control.
8) Record events in system memory.
9) Indicate device in alarm on graphic annunciator.

d. Supervisory signal initiation must be by one or more of the following devices and actions:

1) Valve supervisory switch.
2) Automatic Transfer Switch Not in Auto
3) High- or low-air-pressure switch of dry-pipe sprinkler system.
4) Zones or individual devices have been disabled.
5) Dorm Room Smoke Detectors
6) Duct smoke detectors.
7) Carbon monoxide detectors.

e. System trouble signal initiation must be by one or more of the following devices and actions:

1) Open circuits, shorts, and grounds in designated circuits.
2) Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3) Loss of communication with addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4) Loss of primary power at FACU.
5) Ground or single break in internal circuits of FACU.
6) Abnormal ac voltage at FACU.
7) Break in standby battery circuitry.
8) Failure of battery charging.
9) Abnormal position of switch at FACU or annunciator.
10) Voice signal amplifier failure.

f. System Supervisory Signal Actions:
1) Close associated smoke damper(s) in air ducts of associated air-conditioning duct systems.
2) Identify specific device initiating event at FACU and remote annunciators.
3) After time delay of 200 seconds, transmit trouble or supervisory signal to remote alarm receiving station.
4) Transmit system status to building management system.
5) Display system status on graphic annunciator.

g. Device Guards:

1) Description: Welded wire mesh of size and shape for manual station, smoke detector, gong, or other device requiring protection.

a) Factory fabricated and furnished by device manufacturer.
b) Finish: Paint of color to match protected device.

h. Document Storage Box:

1) Description: Enclosure to accommodate standard 8-1/2-by-11 inch manuals and loose document records. Legend sheet will be permanently attached to door for system required documentation, key

contacts, and system information. Provide two key ring holders with location to mount standard business cards for key contact personnel.
2) Material and Finish: 18-gauge cold-rolled steel; four mounting holes.
3) Color: Red or Black powder-coat epoxy finish.
4) Labeling: Permanently screened with 1 inch high lettering "SYSTEM RECORD DOCUMENTS" with white indelible ink.
5) Security: Locked with 3/4 inch barrel lock. Provide solid 12 inch stainless steel piano hinge.
6) Include an internal 4GB flash drive for system program storage.

2.2 FIRE-ALARM CONTROL UNIT (FACU)

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Gamewell FCI; Honeywell International, Inc. E3 series

B. Description: Field-programmable, microprocessor-based, modular, power-limited design with electronic modules.

C. Performance Criteria:

1. Regulatory Requirements: Comply with NFPA 72 and UL 864.
2. General Characteristics:

a. System software and programs must be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining information through failure of primary and secondary power supplies.
b. Include real-time clock for time annotation of events on event recorder.
c. Provide communication between FACU and remote circuit interface panels, annunciators, and displays.
d. FACU must be listed for connection to central-station signaling system service.
e. Provide nonvolatile memory for system database, logic, and operating system and event history. System must require no manual input to initialize in the event of complete power down condition. FACU must provide minimum 500-event history log.
f. Addressable Initiation Device Circuits: FACU must indicate which communication zones have been silenced and must provide selective silencing of alarm notification appliance by building communication zone.

1) Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: FACU must be listed for releasing service.

g. Fire-Alarm Annunciator: Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.

1) Annunciator and Display: LCD, 640 characters, minimum.

2) Keypad: Arranged to permit entry and execution of programming, display, and control commands.

h. Alphanumeric Display and System Controls: Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.

1) Annunciator and Display: LCD, 16 line(s) of 640 characters, minimum.
2) Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into system for control of smoke-detector sensitivity and other parameters.

i. Signaling-Line Circuits for fire alarm control unit and annunciator communications:

1) Pathway Class Designations: NFPA 72, Class A.
2) Pathway Survivability: Level 1.
3) Install fault circuit isolators to comply with circuit performance requirements of NFPA 72 and manufacturer's written instructions, whichever is more conservative.

j. Signaling-Line Circuits for addressable devices:

1) Pathway Class Designations: NFPA 72, Class A.
2) Pathway Survivability: Level 1.
3) Install no more than 70% available addressable devices addressable devices on each signaling-line circuit.
4) Install fault circuit isolators to comply with circuit performance requirements of NFPA 72 or with manufacturer's written instructions, whichever is more conservative.

k. Initiating-Device Circuits:

1) Pathway Class Designations: NFPA 72, Class A.
2) Pathway Survivability: Level 1.
3) Install no more than one device on each initiating-device circuit.
4) Install fault circuit isolators to comply with circuit performance requirements of NFPA 72 or with manufacturer's written instructions, whichever is more conservative.

l. Notification-Appliance Circuits:

1) Pathway Class Designations: NFPA 72, Class A.
2) Pathway Survivability: Level 1.
3) Install a minimum of two audible and visual notification circuits on each floor.
4) Install adjacent notification appliances to be served from different circuits.

m. Serial Interfaces:

1) One dedicated RS 485 port for supervising station operation using point ID DACT.
2) One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
3) One RS 232 port for PC configuration.

n. Notification-Appliance Circuit:

1) Audible notification appliances must sound in three-pulse temporal pattern, as defined in NFPA 72.
2) Audible notification appliances messages must be synchronized throughout the entire notification zone and between notification zones where notification zones are not physically separated by walls and floors.
3) Where notification appliances provide signals to sleeping areas, alarm signal must be 520 Hz square wave with intensity 15 dB above average ambient sound level or 5 dB above maximum sound level, or at least 75 dB(A-weighted), whichever is greater, measured at pillow.
4) Visual notification appliances must flash in synchronization where multiple appliances are in same field of view, as defined in NFPA 72.

o. Elevator Recall: Initiate by one of the following alarm-initiating devices:

1) Elevator lobby detectors except lobby detector on designated floor.
2) Smoke detectors in elevator machine room.

p. Elevator controller must be programmed to move cars to alternate recall floor if lobby detectors located on designated recall floors are activated.

q. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls must be connected to fire-alarm system.

r. Remote Smoke-Detector Sensitivity Adjustment: Controls must select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory.

s. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to remote alarm station.

t. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as special module that is part of FACU.

u. At least eight of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of central-control microphone. Amplifiers must comply with UL 1711.

1) Audio communication between amplifiers is to be digital.
2) Allow application of, and evacuation signal to, indicated number of zones and simultaneously allow voice paging to other zones selectively or in combination.
3) Programmable tone and message sequence selection.
4) Standard digitally recorded messages for "Evacuation" and "All Clear."
5) Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of FACU.
6) Message storage is capable of storing a minimum of 32 minutes of pre-recorded messages.

v. Status Annunciator: Indicate status of various voice/alarm speaker zones.
w. Preamplifiers, amplifiers, and tone generators must automatically transfer to backup units, on primary equipment failure.
x. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from other printed indications. Also, print system reset event, including same information for device, location, date, and time. Commands initiate printing of list of existing alarm, supervisory, and trouble conditions in system and historical log of events.
y. Primary Power: 24 V(dc) obtained from 120 V(ac) service and power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, and supervisory signals must be powered by 24 V(dc) source.
z. Alarm current draw of entire fire-alarm system must not exceed 80 percent of power-supply module rating.
aa. Secondary Power: 24 V(dc) supply system with batteries, automatic battery charger, and automatic transfer switch.
bb. Batteries: Sealed, valve-regulated, recombinant lead acid.

D. Accessories:

1. Instructions: Computer printout or typewritten instruction card mounted behind plastic or glass cover in stainless steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe functional operation of system under normal, alarm, and trouble conditions.
2. Preaction System Functionality:

a. Initiate Presignal Alarm: This function must cause audible and visual alarm and indication to be provided at FACU. Activation of initiation device connected as part of preaction system must be annunciated at FACU only, without activation of general evacuation alarm.

2.3 MANUAL FIRE-ALARM BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Gamewell FCI; Honeywell International, Inc. MS-7AF Series

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes must be finished in red with molded, raised-letter operating instructions in contrasting color; must show visible indication of operation; and must be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
   1. Double-action mechanism requiring two actions to initiate alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to FACU.
   2. Station Reset: Key operated switch.
   3. Indoor Protective Shield: Where indicated factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm. Lifting cover actuates integral battery-powered audible horn intended to discourage false-alarm operation.
   4. Weatherproof Protective Shield: Where indicated, factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm.
   5. Able to perform at up to 90 percent relative humidity at 90 deg F.
   6. Able to be used in indoor areas.

2.4 SYSTEM SMOKE DETECTORS

A. Photoelectric Smoke Detectors:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Gamewell FCI; Honeywell International, Inc. ASD-PL3 Series

2. Performance Criteria:

   a. Regulatory Requirements:

      1) NFPA 72.
      2) UL 268.

   b. General Characteristics:

      1) Detectors must be two-wire type.
      2) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
      3) Base Mounting: Detector and associated electronic components must be mounted in twist-lock module that connects to fixed base. Provide terminals in fixed base for connection to building wiring.
      4) Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
      5) Integral Visual-Indicating Light: LED type, indicating detector has operated.
      6) Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
      7) Operator at FACU, having designated access level, must be able to manually access the following for each detector:

         a) Primary status.
         b) Device type.

c) Present average value.
d) Present sensitivity selected.
e) Sensor range (normal, dirty, etc.).

8) Detector must have functional humidity range within 10 to 90 percent relative humidity.
9) Color: White.
10) Remote Control: Unless otherwise indicated, detectors must be digital-addressable type, individually monitored at FACU for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by FACU.
11) Rate-of-rise temperature characteristic of combination smoke- and heat-detection units must be selectable at FACU for 15 or 20 deg F per minute.
12) Fixed-temperature sensing characteristic of combination smoke- and heat-detection units must be independent of rate-of-rise sensing and must be settable at FACU to operate at 135 or 155 deg F.
13) Multiple levels of detection sensitivity for each sensor.
14) Sensitivity levels based on time of day.

3. 520 Hz Sensor base with built-in low frequency sounder – All standard base features and piezo electric sounder shall provide a low frequency 520 Hz Square Wave (85 dBA) with nominal current requirements (90 mA). Sounder shall be synchronized via SLC communications or by the NAC if NAC powered, sounder operation shall be programmable and shall be manually operated from FACU.
   a. Emitted tone shall be a 520 Hz Square Wave signal in compliance with the requirements of NFPA 72 for sleeping areas.
   b. The 520 Hz sounder base shall be listed to UL 268 and UL 464, Audible Signal Appliances.

2.5 DUCT SMOKE DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Gamewell FCI; Honeywell International, Inc. DNR Series

B. Description: Photoelectric-type, duct-mounted smoke detector.

C. Performance Criteria:

1. Regulatory Requirements:

   a. NFPA 72.
   b. UL 268A.

2. General Characteristics:

   a. Detectors must be two-wire type.
   b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.

c. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
d. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
e. Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
f. Operator at FACU, having designated access level, must be able to manually access the following for each detector:

1) Primary status.
2) Device type.
3) Present average value.
4) Present sensitivity selected.
5) Sensor range (normal, dirty, etc.).

g. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with supplied detector for smoke detection in HVAC system ducts.
h. Each sensor must have multiple levels of detection sensitivity.
i. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

2.6 HEAT DETECTORS

A. Combination-Type Heat Detectors:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Gamewell FCI; Honeywell International, Inc. ATD-LR3 Series

2. Performance Criteria:

   a. Regulatory Requirements:

      1) NFPA 72.
      2) UL 521.

   b. General Characteristics:

      1) Temperature sensors must test for and communicate sensitivity range of device.

   c. Actuated by fixed temperature of 135 deg F or rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
   d. Mounting: Twist-lock base interchangeable with smoke-detector bases.
   e. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
   f. Detector must have functional humidity range of 10 to 90 percent relative humidity.
   g. Color: White.

B. Fixed-Temperature-Type Heat Detectors:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Gamewell FCI; Honeywell International, Inc. ATD-L3 Series

2. Performance Criteria:

   a. Regulatory Requirements:

      1) NFPA 72.
      2) UL 521.

   b. General Characteristics:

      1) Actuated by temperature that exceeds fixed temperature of 190 deg F.
      2) Mounting: Twist-lock base interchangeable with smoke-detector bases.
      3) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
      4) Detector must have functional humidity range of 10 to 90 percent.
      5) Color: White.

2.7 FIRE-ALARM NOTIFICATION APPLIANCES

A. Fire-Alarm Audible Notification Appliances:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Gamewell FCI Honeywell International, Inc.

2. Description: Bells, or other notification devices that cannot output voice messages.
3. Performance Criteria:

   a. Regulatory Requirements:

      1) NFPA 72.

   b. General Characteristics: where indicated, weatherproof.

B. Fire-Alarm Voice/Tone Notification Appliances:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Gamewell FCI; Honeywell International, Inc. SPSR & SPSCR Series

2. Description: Notification appliances capable of outputting voice evacuation messages.
3. Performance Criteria:

a. Regulatory Requirements:

1) NFPA 72.
2) UL 1480.

b. General Characteristics:

1) Speakers for Voice Notification: Locate speakers for voice notification to provide intelligibility requirements of "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
2) Sound output: selectable in field, 1/4 to 2 W.
3) Mounting: semi-recessed.
4) Matching Transformers: Tap range matched to acoustical environment of speaker location.
5) Combination Devices: Factory-integrated audible and visible devices in single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

C. Fire-Alarm Visible Notification Appliances:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Gamewell FCI; Honeywell International, Inc. SRL & SCRL Series

2. Performance Criteria:

a. Regulatory Requirements:

1) NFPA 72.
2) UL 1971.

b. General Characteristics:

1) Rated Light Output:
   a) Selectable in field, minimum of 15/30/75/95 cd.

2) Clear or nominal white polycarbonate lens mounted on aluminum faceplate.
3) Mounting: Wall mounted unless otherwise indicated.
4) For units with guards to prevent physical damage, light output ratings must be determined with guards in place.
5) Flashing must be in temporal pattern, synchronized with other units.
6) Strobe Leads: Factory connected to screw terminals.
7) Mounting Faceplate: Factory finished, red.

2.8 UL 2524 ERRCES EMERGENCY RESPONDER RADIO COVERAGE SYSTEM

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Gamewell FCI BDA (RSI)

B. Description: Emergency responder radio coverage systems use a combination of bidirectional amplifiers and distributed antenna systems to boost signals for sustaining two-way radio communications throughout a facility, including stairwells, underground tunnels, parking garages, and other challenging areas. A site survey shall be conducted and documented in advance of design submission to ensure design compliance with code requirements and associated complete code coverage.

C. ERRCES emergency responder radio coverage system shall be a point addressable type system and an addressable extension of the Gamewell FCI E3 Series FACU.

D. Performance Criteria:

1. Regulatory Requirements:

a. In accordance with NFPA 72, FCNYS, IFC, emergency responder radio coverage systems must be designed, installed, and maintained in accordance with NFPA 1221.

b. The emergency responder radio coverage system installation and components shall also comply with all applicable federal regulations including, but not limited to, FCC 47 CFR Part 90.219.

2. General Characteristics:

a. Where emergency responder radio coverage system is used in lieu of two-way in-building wired emergency communications system, it must have pathway survivability of Level 1, 2, or 3 as defined in NFPA 72.
b. Where leaky feeder cable is used as antenna, it is not permitted to be used as the antenna.
c. Feeder and riser coaxial cables must be rated as plenum cables.
d. Feeder coaxial cables must be connected to riser coaxial cables using hybrid coupler devices of value determined by overall design.
e. Where emergency responder radio coverage system is used in lieu of two-way in-building wired emergency communications system, design of system must be approved by authorities having jurisdiction. Riser coaxial cables must be rated as riser cables and routed through 2-hour-rated enclosure.
f. Connection between riser and feeder coaxial cables must be made within 2-hour-rated enclosure, and passage of feeder cable in and out of 2-hour-rated enclosure must be firestopped to 2-hour ratings.

2.9 FIRE-ALARM REMOTE ANNUNCIATORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Gamewell FCI; Honeywell International, Inc. E3 Series

B. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:

a. Annunciator functions must match those of FACU for alarm, supervisory, and trouble indications. Manual switching functions must match those of FACU, including acknowledging, silencing, resetting, and testing.

1) Mounting: Flush cabinet, NEMA 250, Type 1.

b. Display Type and Functional Performance: Alphanumeric display and LED indicating lights must match those of FACU. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.10 FIRE-ALARM ADDRESSABLE INTERFACE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Gamewell FCI; Honeywell International, Inc.

B. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:

a. Include address-setting means on module.
b. Store internal identifying code for control panel use to identify module type.
c. Listed for controlling HVAC fan motor controllers.
d. Monitor Module: Microelectronic module providing system address for alarm-initiating devices for wired applications with normally open contacts.
e. Integral Relay: Capable of providing direct signal as required to isolate fire alarm system from other systems.

1) Allow control panel to switch relay contacts on command.
2) Have minimum of two normally open and two normally closed contacts available for field wiring.

f. Control Module:

1) Operate notification devices.
2) Operate solenoids for use in sprinkler service.

2.11 SUPERVISING STATION CONNECTION

A. Digitize “Mux Pad”
1. The Digitize “Mux Pad” shall be furnished and installed by the Contractor. Equipment can be purchased through the local fire alarm representative; contact West Fire Systems, Rochester, NY.

2. A space clear of any other equipment, 24" square adjacent to the main fire alarm control panel is required for the “Mux Pad.” The “Mux Pad” will be mounted at 60" AFF to the center of the device in a dedicated enclosure, and within (5) feet of the fire alarm control panel.
3. Cornell University’s EH&S and Fire Alarm Technicians shall perform the associated final connections to the fire alarm control panel and communication lines.
4. Digitize “Mux Pad” conduit system shall be included in the Contract Documents as part of the Electrical Contract as follows:
    a. One ¾” conduit with nylon dragline from each Mux Pad to designated Cornell University System 85 communication cabinet. Cabling will be installed and connected by Cornell University.
    b. One 3/4" conduit and Digitize Mux Pad interconnecting cable (contractor to purchase from manufacturer) between FACU and the Mux Pad. Cable should be factory pinned for proper fire alarm panel to be connected.

B. Costs, charges, and fees associated with the installation and connection of any leased telephone lines shall be included in the Contractor’s invitation-for-bid proposal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Preinstallation Testing: Perform verification of functionality of installed components of existing system prior to starting work. Document equipment or components not functioning as designed.

B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service in accordance with requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of fire-alarm service.

2. Do not proceed with interruption of fire-alarm service without Owner's written permission.

C. Protection of In-Place Conditions: Protect devices during construction unless devices are placed in service to protect facility during construction.

3.3 INSTALLATION OF EQUIPMENT

A. Comply with NECA 305, NFPA 72, requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment, manufacturer's written instructions, whichever is more conservative. Install electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before other trades have completed cleanup must be replaced.
2. Devices installed, but not yet placed, in service must be protected from construction dust, debris, dirt, moisture, and damage in accordance with manufacturer's written storage instructions.

B. Equipment Floor and Wall Mounting: Install FACU on finished floor.

1. Comply with requirements for seismic-restraint devices per Cornell’s standards and as specified in Section 270548.16 "Seismic Controls for Communications Systems."

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inch above finished floor.

1. Comply with requirements for seismic-restraint devices per Cornell’s standards and as specified in Section 270548.16 "Seismic Controls for Communications Systems."

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in normal path of egress within 60 inch of exit doorway.
2. Mount manual fire-alarm box on background of contrasting color.
3. Operable part of manual fire-alarm box must be between 42 and 48 inch above floor level. Devices must be mounted at same height unless otherwise indicated.

E. Smoke- and Heat-Detector Spacing:

1. Comply with "Smoke-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with "Heat-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing must not exceed a nominal 30 ft..
4. Smoke detectors must be located to not exceed 21 ft. (0.7 times the nominal distance).
5. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas must be determined in accordance with Annex Ain NFPA 72.

6. HVAC: Locate detectors not closer than 36 inch from air-supply diffuser or return-air opening.
7. Lighting Fixtures: Locate detectors not closer than 12 inch from lighting fixture and not directly above pendant mounted or indirect lighting.
8. Elevator: Locate detectors within 21 ft. of elevator door.
9. Fire alarm equipment: Comply with NFPA 72. Locate detectors within 21 ft. of each control unit, notification appliance circuit power extender and supervising station transmitting equipment.

F. Install cover on each smoke detector that is not placed in service during construction. Cover must remain in place except during system testing. Remove cover prior to system turnover.

G. Duct Smoke Detectors: Comply with NFPA 72. Install sampling tubes so they extend full width of duct. Tubes more than 36 inch long must be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
2. Install duct smoke detector associated smoke or combination fire/smoke damper within 60 inch (1520 mm).
3. Locate duct smoke detectors so access for maintenance can be performed in accordance with OSHA and without any special equipment.
4. Test the detectors in accordance with the manufacturer’s written instructions including pressure differential measurements.

H. Air-Sampling Smoke Detectors: If using multiple pipe runs, runs must be pneumatically balanced.

I. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

J. Stairways: Locate fire alarm equipment in stairways directly above the landing to facilitate maintenance of equipment.

K. Electrical Equipment: Avoid locating fire alarm equipment above high voltage electrical equipment.

L. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within dwelling or suite, they must be connected so that operation of smoke alarm causes alarm in smoke alarms to sound.

M. Remote Status and Alarm Indicators: Install in visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position. Final location approval to be coordinated with EH&S

N. Audible Notification Appliances: Comply with "Audible Characteristics " section in "Notification Appliances" chapter in NFPA 72.
1. Install audible notification on flush-mounted back boxes with device-operating mechanism concealed behind grille.
2. Install devices at same height unless otherwise indicated.

O. Visual Notification Appliances: Comply with "Visual Characteristics – Public Mode" section in "Notification Appliances" chapter in NFPA 72.
   1. Install visual notification on flush-mounted back boxes with device-operating mechanism concealed behind grille.
   2. Install devices at same height unless otherwise indicated.

P. Combination Audible and Visual Notification Appliances Comply with "Audible Characteristics" and "Visual Characteristics – Public Mode" section in "Notification Appliances" chapter in NFPA 72.
   1. Install visual notification on flush-mounted back boxes with device-operating mechanism concealed behind grille.
   2. Install devices at same height unless otherwise indicated.

Q. End of Line Resistors: Install factory terminated end of line resistor harnesses.
   1. Locate end of line resistors in floor terminal cabinet at the riser for all circuits with multiple devices or appliances
   2. For circuits monitoring a single device or appliance, the end of line resistor is allowed to be installed within the device enclosure.

R. Device Location-Indicating Lights: Locate in public space near door that provides access to the room they monitor.

S. Transient Voltage Surge Suppressors: Install in a dedicated enclosure.
   1. Locate transient voltage surge suppressor within room serving protected equipment.
   2. Install on each circuit serving fire alarm equipment.

T. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that resists wind load of 100 mph with gust factor of 1.3 without damage.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate must be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
   2. Nameplate must be laminated acrylic or melamine plastic signs with black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.6 PATHWAYS

A. Pathways must be installed in EMT.

B. Exposed EMT must be painted red enamel.

3.7 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with supervised interface device to the following devices and systems. Install interface device less than 36 inch from device controlled. Make addressable confirmation connection when such feedback is available at device or system being controlled.
1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors and access gates.
4. Alarm-initiating connection to elevator recall system and components.
5. Alarm-initiating connection to activate emergency lighting control.
6. Supervisory connections at valve supervisory switches.
7. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
8. Data communication circuits for connection to building management system.
9. Data communication circuits for connection to mass notification system.

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and the following requirements:

1. All loop wiring and cabling shall be labeled with laser printer labels indicating the feed and return for all cabling located at the fire alarm control units, transponders, and terminal cabinets. All labels shall be attached to a rigid plastic backing.

2. A signaling circuit shall be identified with the circuit number at all terminations at individual devices.
3. All addressable devices shall be labeled with laser printer labels indicating their device address and the FACU that serves that device.
4. All interior notification appliances shall be labeled with laser printer labels indicating their appliance circuit number and designation number.
5. All batteries shall be labeled with laser printer labels indicating the installation date when batteries were first energized and the required replacement date per the manufacturer's recommendations.
6. Each addressable device shall be labeled with a permanent label indicating the device's address. Detector bases shall be labeled on one side.
7. All FACUs and remote power supplies shall be provided with a label on the inside cover indicating the location of the circuit breaker.
8. The primary Fire Alarm Control Units shall be marked with signage indicating 'Balch Hall Fire Alarm Control Unit Node #1" with 2" letters, engraved or laser printed, white on red or red on white.
9. All fire alarm control units shall be labeled as "Fire Alarm Control Unit Node #_" with ½" letters, engraved or laser printed, white on red or red on white.
10. Contractor shall provide additional laser printed labels ½" letters for all other non-labeled equipment in the fire command center including terminal cabinets, data gather panels etc.
11. All Notification Appliance Remote Power Supplies shall be equipped with a laser printer label indicating Fire Alarm NAC Panel Number, on the outside of the enclosure.
12. Metal weatherproof signage shall be provided for all new exterior water indicating bells indicating "SPRINKLER WATER FLOW ALARM WHEN BELL RINGS CALL FIRE DEPARTMENT" in 2" letters, white letters on red background, final signage to be approved by owner and Ithaca Fire Department prior to purchase.
13. Remote alarm indicators shall be labeled with the addressable device designator identification number.
14. The contractor shall provide simplified color floor plans showing locations of stairs, elevators, and fire alarm equipment. The plans shall be laminated and installed near the annunciator in the fire command center. The plan shall be at least on 8½"x11" paper but no larger than 11"x17".

B. All rooms with detectors shall be provided with signage that is approved by the Owner Install framed instructions in location visible from FACU.

3.9 GROUNDING

A. Ground FACU and associated circuits in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Ground shielded cables at control panel location only. Insulate shield at device location with heat shrinkable tubing or equal.

3.10 FIELD QUALITY CONTROL

A. Field tests must be witnessed by Owner, authorities having jurisdiction and Engineer.
1. Provide minimum (72) hours prior to notice to EH&S and AHJ.

2. Complete and submit program sheets to EH&S.
3. Ensure that system is pre-tested.
4. Contractor to provide all testing equipment.
5. Smoke detectors shall be tested by smoke that is approved by the manufacturer.
6. Rate-of-rise heat detectors shall be tested by heat.
7. Fixed temperature detectors shall be tested by shorting alarm contacts.

B. Administrant for Tests and Inspections:
   1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

C. Tests and Inspections:

   1. Visual Inspection: Conduct visual inspection prior to testing.

      a. Inspection must be based on completed record Drawings and system documentation that is required by "Completion Documents, Preparation" table in "Documentation" section of "Fundamentals" chapter in NFPA 72.
      b. Comply with "Visual Inspection Frequencies" table in "Inspection" section of "Inspection, Testing and Maintenance" chapter in NFPA 72; retain "Initial/Reacceptance" column and list only installed components.

   2. System Testing: Comply with "Test Methods" table in "Testing" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
   3. Test audible appliances for public operating mode in accordance with manufacturer's written instructions. Perform test using portable sound-level meter complying with Type 2 requirements in ASA S1.4 Part 1/IEC 61672-1.
   4. Test audible appliances for private operating mode in accordance with manufacturer's written instructions.
   5. Test visible appliances for public operating mode in accordance with manufacturer's written instructions.
   6. Factory-authorized service representative must prepare "Fire Alarm System Record of Completion" in "Documentation" section of "Fundamentals" chapter in NFPA 72 and "Inspection and Testing Form" in "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

I. Project shall include two reprograms of the system by the Manufacturer's Representative after the panel has been accepted by Cornell University's Environmental Health & Safety at no additional cost, charge, or fee to Cornell University.

3.11 DEMONSTRATION

A. The Basis of Design for this project is a Gamewell/FCI E3 Series network addressable fire control unit and UL listed peripheral devices as noted in the contract documents. This for which, Cornell University technicians hold factory training certifications. If fire detection control and peripheral equipment other than the above design basis is provided, the fire alarm supplier must include the cost of factory technical training and sublicensing for a minimum of (2) Cornell University technicians inclusive of study materials and any applicable e-learning prerequisite courses. At the training conclusion, the Cornell University technicians shall hold the same manufacturers technician training certification as the fire alarm equipment providers service technicians. If fire detection control and peripheral equipment other than the above design basis is provided, the fire alarm supplier must also include the cost of providing two days of onsite end user training for Cornell University's fire alarm test & inspection department. This training to include all relevant documentation pertaining to this project for a minimum of (6) students.

3.12 MAINTENANCE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service must include 24 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections in accordance with "Visual Inspection Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in "Test Methods" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per "Testing Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.13 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement must include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software must include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

End of Section

SECTION 31 00 00

EARTHWORK

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Work of this Section, as shown or specified, shall be in accordance with the requirements of the Contract Documents.

1.2 SECTION INCLUDES

A. The Work of this Section includes all labor, materials, equipment and services necessary to complete the earthwork as shown on the drawings and/or specified herein, including but is not necessarily limited to the following:
   1. Lay out and stake all lines and levels.
   2. Protection and safeguards.
   3. Clearing and grubbing
   4. Stripping and stockpiling topsoil
   5. Earth open excavation for pavement subgrades.
   6. Trench earth excavation for utilities.
   7. Site grading.
   8. Backfilling utility trenches and utility structures.
   9. Backfilling of building foundation structures and site retaining walls.
   10. Subsurface drainage on site and under concrete slabs-on-grade.
   11. Embankment for pavement subgrade.
   12. Aggregate base course for asphalt and concrete pavement.
   13. Disposal of unsuitable and excess excavated materials.
   14. Preparation of sub-grade for walks, pavements and landscape areas to receive topsoil, seeding, and planting.
   15. Dewatering.
   16. Shoring and bracing.
   17. Protection of adjacent existing structures, utilities and other facilities against damage from the Work.

1.3 RELATED SECTIONS

A. Division 01 through Division 33 Sections.
   1. Temporary Fencing - Section 01 5626
   2. Site Construction Performance Requirements – Section 01 8900
   3. Selective Site Demolition – Section 02 4113
   4. Cast-in-Place Concrete – Section 03 3300
   5. Pneumatic Excavation – Section 31 1317
   6. Subgrade Preparation in Planting Areas – Section 31 2312
   7. Mud and Other Soil Debris – 31 2550
   8. Asphalt Pavement – Section 32 1216
   9. Cement Concrete Pavement – Section 32 1313
   10. Stone Curbs – Section 32 1640
   11. Planting Soils – Section 32 9113

12. Landscape Grading – 32 9119
13. Seeded Turf – Section 32 9200
14. Planting – Section 32 9300
15. Chilled Water Distribution – Section 33 1400
16. Sanitary Sewerage – Section 33 3000.
17. Storm Sewerage – Section 33 4000.

1.4 **F**IELD MEASUREMENTS

A. Verify that survey benchmark and intended elevations for the Work are as indicated.

B. Coordinate with the requirements of Section 01 8900 Site Construction Performance Requirements

1.5 REFERENCES

A. ASTM D2922 - Test Methods for Density of Soil and Soil Aggregate in Place by Nuclear Methods.

B. 12 NYCRR 53 - Construction, Excavation, and Demolition Operations At or Near Underground Facilities.

C. New York State Department of Transportation - Standard Specifications, Construction and Materials current edition.

1.6 DEFINITIONS

A. Rock Excavation: Removal of solid mineral material or obstruction that cannot be excavated with a modern track-mounted power shovel equivalent to Caterpillar Model No. 215C LC, and rated at not less than 125 HP flywheel power and 33,075 pound draw-bar pull and equipped with a short stick and 42 inch wide short tip radius rock bucket rated at 0.81 cubic yard capacity.

B. Unclassified Excavation: Removal of obstructions visible on the surface, topsoil, earth, and all other subsoil materials encountered that are not defined as Rock Excavation.

C. Subgrade Surface: The undisturbed earth or the compacted soil layer immediately below granular subbase, base of structure, or topsoil materials.

D. Structure: Buildings, foundations, slabs, tanks, manholes, or other constructed or manufactured stationary features occurring above or below ground surface.

E. Utility: Any buried pipe or conduit.

F. Pavement: Any compacted granular, asphalt concrete or portland cement concrete section, either existing or proposed, constructed above the subgrade surface for the purpose of supporting pedestrian or vehicular traffic.

1.7 REGULATORY REQUIREMENTS

A. Submit to Owner a signed fill agreement or property owner release for deposit of any unsuitable and excess excavation materials disposed of off site.

B. Comply with 29 CFR Part 1926, OSHA, Subpart P, Excavations and Trenches for work of this section.

C. Submit to City of Ithaca a haul route plan for removal of surplus excavation material. Obtain signed approval from City Engineer before commencing off-site hauling activities.

1.8 SUBMITTALS

A. Materials Source: Submit name and address of imported aggregate materials suppliers. Provide materials from same source throughout the Work. Change of source requires Engineer approval.

B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance with the following with requirements indicated:

1. Classification according to ASTM D2487 of each on-site or borrow soil material proposed for fill and backfill.

2. Laboratory compaction curve test results according to ASTM D1557 (Modified Proctor) for Structural Fill and Base Course materials.

3. Laboratory sieve analysis test results according to ASTM C136 for all imported granular materials.

1.9 PROJECT CONDITIONS

A. Existing Utilities: Locate, identify, and protect utilities that remain, from damage. Be assured as to the location and position of gas, water, sewer, electric, telephone services and mains, culverts and other conduits that may be affected by the construction and notify the respective authorities in charge of same of the work in the vicinity. CALL Dig Safely New York (former Underground Facilities Protective Organization) 1-800-962-7962 and Cornell Facilities BEFORE STARTING EXCAVATION OPERATIONS. The Contractor will be held strictly responsible for the cost of repairs or replacement of all utilities and other conduits damaged directly by his forces or indirectly by failure to provide proper protection or support of the same. The Contractor will also be held responsible for damages to others caused by utility lines damaged either directly or indirectly by his operations. Comply with all rules and regulations cited in 12 NYCRR 53 - Construction, Excavation and Demolition Operations At or Near Underground Facilities.

B. If uncharted, or incorrectly charted, piping or other utilities are encountered during excavation, consult utility authority and Owner immediately for direction. Cooperate with Owner and utility authority to keep their respective services and facilities in operation.

C. Dust Control
1. Use all means necessary to control dust on or near the work.
2. Thoroughly moisten all surfaces as required to prevent dust being a nuisance to the public, neighbors, and performance of other work on the site.
3. The use of Calcium chloride for dust control is prohibited on this project.

D. Protection
1. Barricade open excavations occurring as part of this work and post with warning lights. Operate warning lights as recommended by authorities having jurisdiction.
2. Provide the necessary safeguards to prevent accidents, to avoid all unnecessary hazards and protect the public, the work and the property at all times, including Saturdays, Sundays and holidays.
3. Be responsible for any and all damages which may arise or occur to any party whatsoever by reason of the neglect in providing proper lights, guards, barriers, or any other safeguards to prevent damage to property, life and limb.

4. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

E. Use of explosives is not permitted.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General Requirements

1. Borrow shall contain salt levels less than 1.0 milliohms/cm as measured by electrical conductivity (EC2) of a 1:2 soil-water suspension (Test minus sieve #4 material.). Backfill and fill materials with levels of salt in excess of this level will be considered unsuitable material and shall be removed from the site by the Contractor at no additional cost to the Owner.

2. Borrow shall not contain asbestos, or other contamination at concentrations above background levels for natural soils as published by the NYSDEC. Borrow material with asbestos, or other contamination at concentrations above indicated background levels, will be considered unsuitable material and shall be removed by the Contractor from the site and disposed of legally at no additional cost to the Owner.

B. Satisfactory Soils: Soil Classification Groups GW, GP, SW, **and** SP according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 3 inches (75 mm) in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

1. Liquid Limit: ≤20, and,

2. Plasticity Index: ≤4.

C. Unsatisfactory Soils: Soil Classification Groups GM, GC, SM**,** SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Structural Fill: Subbase Course Material (Type 4).

E. Subbase Course Material (Type 2): Naturally or artificially graded crushed ledgerock which is sound, durable, and free of organic and other deleterious materials conforming to N.Y.S.D.O.T. Item 733.0402. Material to have 20 percent or less loss after 4 cycles of N.Y.S.D.O.T. Magnesium Sulfate Soundness Test.

F. Subbase Course Material (Type 4): Naturally or artificially graded crushed bank-run gravel which is sound, durable, and free of organic and other deleterious materials conforming to the limits of gradation for N.Y.S.D.O.T. Item 733.0404.

G. Bedding Stone: Clean, sound, durable, sharp-angles fragments of rock of uniform quality and conforming to NYSDOT Material Designation 703-0201, Size Designation No. 1 or 1A.

H. Drainage Stone: Clean, sound, durable, sharp-angled fragments of rock of uniform quality and conforming to NYSDOT Material Designation 703-0201, Size Designation No. 2.

I. Cushion Sand: Clean, hard, durable, uncoated particles, free from lumps of clay and all deleterious substances conforming to the following limits of gradation when dry:

Percent Passing by Weight	Sieve Size
100	1/4 inch
0 to 35	No. 50
0 to 10	No. 100

J. Select Fill: Imported or excavated on-site sand, loam, or clay material free from organic material and debris. Unfrozen and containing only small amounts of rock not exceeding four inches in the largest dimension.

K. Bioretention Planting Soil: Uniform blend of 1 part Topsoil, 1 to 3 parts Sand and 0 to 1 part Compost by weight.

1. Topsoil: As specified in Section 329113
2. Sand: ASTM C33 with effective size of 0.25mm to 1.0mm and uniformity coefficient less than or equal to 4. All sand to pass the ¼-inch sieve.
3. Compost: As specified in Section 329113
4. Texture (ASTM C136) of the Bioretention Planting Soil mixture with percent passing by weight to be as follows:
   a. Sand (0.075-2.0mm): 75%-85%
   b. Fines (<0.075mm): 15%-25%
   c. No. 4: (4.75mm): 100%
5. Organic Matter: To be between 3% and 5% by weight.
6. Phosphorus Index: To be less than 30.

L. Rip-Rap: Field stone cobbles of uniform quality and nominal spherical dimensions as shown on the Drawings.

M. Structural Soil: A mixture of crushed stone, clay loam, hydrogel and amendments meeting the requirements of “CU Structural Soil®” patented by Cornell University (Patent #5,849,069) also known as “CU SoilTM”. Material shall meet the requirements of NYSDOT Item 610.14000011 Structural Soil Mix. The material shall be obtained from a Producer sublicensed by Amereq, the exclusive Licensee of Cornell University for CU-Structural Soil®. Proof of such sub-licensing shall be submitted to the Engineer along with a sample of the finished mix, prior to delivery to the site. For a list of licensed CU Soil™ producers, call AMEREQ, Inc. @ 1-800-832-8788.

2.2 GEOTEXTILE MATERIALS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:
1. Amoco Fabrics and Fibers Co.
2. Hoechst Celanese Corp.
3. Nicolon Mirafi Group

B. Soil Stabilization Fabric: Provide a woven or nonwoven fabric consisting of continuous chain polymeric filaments or yarns of polyester;similar to Mirafi 500X; with the following certifiable property values:

Property	Minimum Value	Test Method
Puncture Strength	90 lbs.	ASTM D 6241
Mullen Burst Strength	400 psi	ASTM D 3786
Grab Tensile Strength	200 lbs.	ASTM D 4632
Equivalent Opening Size (sieve)	40	US Std. Sieve

C. Filter Fabric: Nonwoven geotextile, specifically manufactured as a drainage geotextile; similar to Mirafi 140N; made from polyolefins, polyesters, or polyamides; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:

Property	Value
Puncture Resistance (lb.)	65
Tear Strength (lb)	50
Grab Tensile Strength (lb.)	120
Apparent Opening Size (sieve)	70
Water Flow Rate (gpm/sf)	135

2.3 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying, underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility. Provide tape colors to utilities as follows:
1. Red: Electric
2. Yellow: Gas, oil, steam and dangerous materials
3. Orange: Telephone and other communications
4. Blue: Water systems
5. Green: Sewer systems

B. Tracer Wire: Copper clad steel, #12 AWG, with minimum 450 lbs. break load and minimum 40 mil insulation thickness. See additional requirements for tracer wiring for water system in Section 331000 - Water Distribution.

2.4 EROSION AND SEDIMENT CONTROLS

A. Silt Fence: Fence structure with woven fabric comprised of high tenacity polypropylene yarns, and a plastic net backing for additional support prefabricated with 1-1/4” nominal square hardwood posts at maximum 8’ intervals and ready for installation upon delivery. Product: Mirafi Envirofence, as manufactured by Ten Cate Nicolon.

B. Erosion Control Blanket: Flexible, open weave blanket manufactured from straw and photodegradable polypropylene multifilament and tape yarns woven into a dimensionally stable matrix. Product: Landlok S2, as manufactured by Synthetic Industries,.

C. Turf Reinforcing Mat: Flexible, open weave mat manufactured from UV stabilized polypropylene multifilaments woven into a dimensionally stable matrix with allowable flow

velocities of 9 ft/s (unvegetated) and 16 ft/s (vegetated). Product: P300, as manufactured by North American Green.

D. Stabilized Construction Entrance Aggregate: Clean, sound, durable, sharp-angled fragments of rock of uniform quality and 3 inch nominal spherical dimension.

E. Silt Log Filter Sock: Biodegradable cotton sock, 12-inch minimum diameter, 1/8-inch mesh opening and minimum 200 psi tensile strength.

2.5 SOURCE QUALITY CONTROL

A. Provide and pay for tests and analysis of aggregate material performed in accordance with ASTM C136 and ASTM D698.

B. If tests indicate materials do not meet specified requirements, change materials and retest.

PART 3 - EXECUTION

3.1 PREPARATION

A. Identify required lines, levels, contours, and datum. Layout the Work in accordance with baseline data shown on Drawings. Refer to the requirements of Section 01 8900 Site Construction Performance Requirements.

B. Protect vegetation, lawns, and other features remaining as a portion of final landscaping.

C. Protect all temporary benchmarks, control points, property monuments, existing structures and fences, from excavation equipment and vehicular traffic.

D. Saw-cut existing pavements in straight lines in advance of excavation.

E. Pre-Construction Meeting. Conduct Pre-construction meeting in accordance with the requirements of this Section.

F. Protection Fencing. Install the protection fencing in the locations shown on the Contract Documents and in accordance with Section 01 5626 Temporary Fencing.

3.2 EXAMINATION

A. Verify that grades and elevations of pavement subgrade are correct prior to requesting proof rolling observation.

B. Provide minimum of 48 hour notice to Engineer for proof rolling the pavement subgrade. Verify that Engineer has observed proof rolling and that testing agency has completed compaction tests prior to placing aggregate courses.

C. Conduct survey and document conditions of buildings near locations of rock removal prior to blasting. Photograph existing conditions identifying existing irregularities.

3.3 CLEARING AND GRUBBING

A. Trees, shrubs, stumps, brush, grasses, turf, herbaceous plants, downed timber, rubbish, organic matter, miscellaneous vegetation or extraneous debris not indicated on the Contract Documents or designated in the field by the Owner’s Representative to remain shall be cleared and grubbed.

B. Clearing shall include the felling, cutting, and satisfactory disposal of all trees, shrubs, branches, litter, stumps, roots and vegetative debris produced through the clearing and grubbing operations.

C. Fell trees in such a way as to not injure trees to be saved. Excavation or grading within the branch spread of trees to be saved shall be performed only under the direction of the Owner's Representative unless otherwise directed.

D. Stumps shall be removed to their full depth. Roots 3 inches and larger shall be removed to a depth of 2 feet below finished grade. Stumps shall be legally disposed of off-site.

3.4 STRIPPING AND STOCKPILING TOPSOIL

A. Strip existing topsoil to avoid integration of subsoil or subgrade material into stockpiles in accordance with the requirements of this Section.

B. Stripping by machine will not be permitted in the vicinity of trees to remain and existing utilities which might be disturbed or damaged during stripping operations.

C. Strip all topsoil to their full depth within the Contract limits. Strip all unsuitable material to its full depth. Protect topsoil from contamination from other unsuitable materials.

D. All stockpiled topsoil shall be tested for suitability as a component of planting soil as specified, performed and paid for in Section 32 9113 Planting Soil. If existing topsoil is deemed unsuitable for reuse under the work of Section 32 9113, it may be used as ordinary fill if it meets the requirements of suitable fill as specified in this Section.
   1. Topsoil borrow that is deemed by the Owner's Representative to be suitable for reuse on site as a component of planting soil shall be mechanically screened through a ¾ inch by 6 inch screen prior to stockpiling operation. Remove and discard all debris left from the screening operation off site in a legal manner.]
   2. Topsoil and planting soil that is determined to be dry shall be wetted by irrigation, left to soften and become freely draining. Only then will the Landscape Architect inspect the topsoil or planting soil to determine whether they are debris.
   3. Existing topsoil shall be deemed unsuitable and shall be removed from the site and legally disposed if one of the following cannot be achieved:
      a. Topsoil which is not suitable for use as specified in this Section.
      b. Topsoil which is not suitable for reuse under the work of Section 32 9113 as a component of planting soil.
   4. Contractor shall not remove existing topsoil from the contract limits of Work without the written approval of the Owner's Representative
   5. Strip topsoil within drip line of trees only where indicated or directed. Notify Owner's Representative prior to any excavation.
   6. Maintain existing grade within drip line of trees, unless otherwise indicated.
   7. Place no fill within the drip line of existing trees unless otherwise shown on the Drawings.

3.5 STOCKPILING TOPSOIL

A. The Contractor shall segregate stripped topsoil into stockpiles depending on the type and reuse potential of the material. At a minimum, the following materials shall be segregated separately:

B. Stockpile topsoil in windrows in areas shown on the Plans. Windrows shall be no greater than 6-feet tall. Prevent erosion by placing windrows with long axes parallel to underlying contour.

3.6 AGGREGATE STOCKPILING

A. Stockpile materials on site adjacent to areas of work.

B. Stockpile in sufficient quantities to meet project schedule and requirements.

C. Separate differing materials with dividers or stockpile apart to prevent mixing.

D. Direct surface water away from stockpile site so as to prevent erosion or deterioration of materials.

3.7 EXCAVATION

A. No excavated material shall be deposited within existing tree protection zones. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water away from existing drainage structures, ponds, basins, or wetland areas. Cover stockpiles to prevent wind-blown dust.

B. Excavation is unclassified and includes excavation to subgrade elevations indicated, regardless of character of materials and obstructions encountered.

C. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimension without specific direction of Geotechnical Engineer. Unauthorized excavation, as well as remedial work directed by Geotechnical Engineer, shall be at Contractor's expense.

1. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position, when acceptable to Geotechnical Engineer.
2. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of same classifications, unless otherwise directed by Geotechnical Engineer.

D. Additional Excavation: When excavation has reached required subgrade elevations, notify Geotechnical Engineer who will make an inspection of conditions.

1. If unsuitable bearing materials are encountered at required subgrade elevations, carry excavations deeper and replace excavated material as directed by the Geotechnical Engineer. Excavation of unsuitable material must extend laterally beyond the edge of the footing or slab for a distance equal to or greater than the required depth of the excavation.
2. Removal of unsuitable material and its replacement as directed will be paid on basis of contract conditions relative to changes in work.

E. Perform excavation with drip line of large trees to remain by hand, and protect the root system from damage or dryout to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with burlap. Paint root cuts of one (1) diameter and larger with emulsified asphalt tree paint.

F. Rock Excavation:

1. Excavate and remove rock by mechanical method. Utilize hydraulic ramming equipment to fracture rock.
2. Provide uniform surface for placement of structure or utility bedding material.
3. Excavate to 6 inches below pipe barrel invert and a minimum 6 inches beneath outside diameter of bell and spigot pipe joints.
4. Correct areas of utility trench over-excavated with compacted bedding material.
5. Provide bedding material of the type and depth specified for the utility and in accordance with the Drawings.
6. Remove from the site or reuse excavated rock material. Dispose of excess excavated rock material in compliance with all local, state and federal regulations.

G. Stability of Excavations: Slope sides of excavations to comply with local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible because

of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling.

H. Shoring and Bracing: Provide materials for shoring and bracing, such as sheet piling, uprights, stringers, and cross braces, in good serviceable condition.

1. Establish requirements for trench shoring and bracing to comply with local codes and authorities having jurisdiction.
2. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Carry down shoring and bracing as excavation progresses.

I. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.

1. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations. Maintain water levels below base of excavation to control hydrostatic pressure on subgrade soils.
2. Establish and maintain temporary drainage ditches and other diversion outside excavation limits to convey rain water and water removed from excavations to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches. Provide temporary erosion and sediment control.
3. Do not discharge sediment laden water into the adjoining storm or sanitary sewer system or open swales. Pump sediment laden water from excavations into a portable sediment tank or a high-strength, non-woven geotextile fabric bag. Size portable sediment tanks in accordance with the New York Guidelines for Urban Erosion and Sediment Control.

J. Material Storage: Stockpile satisfactory excavated materials where directed until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.

1. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.
2. Dispose of excess soil material and waste materials not re-used.

3.8 OPEN EXCAVATION

A. Excavate subsoil required to accommodate site and roadway grades.

B. Machine slope banks to angle of repose or less, until shored.

C. Grade top perimeter of excavation to prevent surface water from draining into excavation.

D. Notify Geotechnical Engineer of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.

E. Correct areas over-excavated with structural fill.

F. Pile excavated material in manner that will not endanger the Work and that will avoid obstructing drives, temporary ditches or natural water courses, or create erosion or landslide hazards.

G. Remove from site all excess excavated materials and dispose of material in compliance with all local, state and federal regulations.

3.9 TRENCH EXCAVATION

A. Excavate topsoil from trench area to be further excavated.

B. Stockpile topsoil to be reused in a designated area on-site.

C. Excavate subsoil to full depth and grade to accommodate the laying of utilities and setting structures.

D. Cut trenches sufficiently wide to enable installation of trench box, shoring, forms, utilities, and to allow inspection. Provide ample trench width to permit placing of fittings and thrust blocking. Maximum and minimum trench width for utilities in accordance with Drawings.

E. Provide uniform surface of solid and undisturbed subgrade for placement of utility or bedding material. Hand trim excavation for bell and spigot pipe joints. Remove loose matter.

F. Excavate to depth required below pipe invert.

G. Remove ledge rock, boulders, and large stones greater than 6 inch diameter, to provide clearance of 6 inches below and 8 inches on each side of all utility pipes and fittings.

H. Correct areas of utility trench over-excavated with compacted structural fill.

I. Provide bedding material of the type and depth specified for the utility and in accordance with the Drawings.

J. Remove from site all excess excavated materials and dispose of material in compliance with all local, state and federal regulations.

3.10 SITE GRADING

A. Traffic of men and equipment across soil subgrade areas shall be prohibited following excavation to the required lines and grades.

B. No stones larger than 3 inches in largest dimension shall be placed in upper 6 inches of the subgrade. Fill shall be left in a compacted state at the end of the workday and sloped to drain.

C. General: Uniformly grade areas within project limits including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are indicated, or between such points and existing grades.

D. Grading Outside Building Lines: Establish subgrade adjacent to building lines to drain away from structures and to prevent ponding.

1. Lawn or Unpaved Areas: Finish areas to receive topsoil to within not more than 1-1/2” above or below required subgrade elevations.

3.11 SUBGRADE PREPARATION AND PROTECTION – LANDSCAPE AREAS

A. Landscape Areas: Preparation of subgrade in landscape area, including planting beds and areas of turf establishment, shall be in accordance with Section 32 2313 Subgrade Preparation in Planting Areas.

1. All areas of the site that will become lawn or plant beds and have been subjected to any foot or vehicular traffic, equipment storage or material stockpiling during the work of this Contract shall be decompacted to a depth of 24 inches as directed by the Landscape Architect.

2. Vertically and laterally fracture all subgrade areas through deep ripping to restore soil porosity and permeability.

3. Do not fracture soil when it is exceptionally wet or dry. Effective fracturing of the subgrade is only achieved when the soil material is moderately dry to moderately moist.

4. In the presence of the Landscape Architect, perform field analysis of soil moisture conditions in the following manner:
    a. Auger or dig a hole in the subgrade to a depth of 24 inches. Reach in and extract a handful of soil.
    b. Hand roll the sample between the palms down to a 1/8-inch diameter snake. If the soil sample crumbles apart in segments no greater than 3/8 of an inch long when it is rolled down to 1/8-inch diameter, it is low enough in moisture for deep ripping.
    c. Conversely, if the rolled sample stretches out into increments that are greater than 3/8-inches long then the soil is too moist and plastic for deep ripping.
5. If the soil is at the proper moisture content then de-compact the landscape area by deep ripping, backhoe excavation or other method approved by the Landscape Architect. Decompact to a depth of 24 inches.
6. Re-compact the subgrade in landscape areas to reduce settling but not too much to prevent the movement of water and feeder roots into the subgrade. The subgrade should feel firm to the foot in all areas and make only slight heel prints. Re-compact the subgrade by driving a small, tracked bulldozer over the area at low speeds so that the tracks of the bulldozer pass over the decompacted area and the soil is compacted to a density that will percolate as specified below.
7. Under no circumstances shall wheeled vehicles be driven over subsoil, placed fills or ordinary borrow that have been shown to percolate or subsoil, placed fills or ordinary borrow that has been loosened and shown to percolate.
8. Percolation testing to verify subgrade soils drain water:
    a. Dig a hole in the re-compacted soil that is a minimum of 8 inches in diameter and 8 inches deep.
    b. Fill the hole with water and let it drain completely. Immediately refill the hole with water and measure the rate of fall in the water level.
    c. In the event that the water drains at a rate less than one inch per hour, de-compact the soil again to a depth required to break the over compaction.
    d. Perform a minimum of one soil percolation test per 10,000 square feet area of turf area and 2,500 square feet of tree and shrub planting area as directed by the Landscape Architect.

3.12 BACKFILLING TRENCHES AND UTILITY STRUCTURES

A. Backfill excavated areas under existing and proposed pavements, including driveways to subgrade elevations with structural fill. Place backfill from top of bedding material to pavement subgrade in maximum 8 inch lifts, each lift compacted at or above 95 percent maximum Modified Proctor density.

B. Backfill excavated areas adjoining structures up to subgrade elevation with structural fill unless shown otherwise on Drawings. Place backfill in maximum 6 inch lifts, each lift compacted at or above 95 percent maximum Modified Proctor density.

C. Backfill excavated areas under lawns or improved areas to topsoil subgrade with select fill. Place backfill from top of bedding material to topsoil subgrade in maximum 12 inch lifts, each lift compacted at or above 92 percent maximum density.

D. Employ placement and compaction methods that do not disturb or damage adjacent work.

E. Maintain moisture content of backfill material within ±2 percent of optimum to attain required compaction density.

F. Do not backfill with frozen material or where the material already in the excavation is frozen.

G. Remove from site all excess excavated materials and dispose of material in compliance with all local, state and federal regulations.

3.13 BACKFILLING SITE RETAINING WALLS

A. Confirm completion of foundation underdrain system prior to placing backfill material. Confirm concrete structure has attained full retaining strength prior to placing backfill material. Backfill excavated areas under existing and proposed pavements, including driveways and walks to subgrade elevations with structural fill. Place backfill from top of underdrain system to pavement subgrade in maximum 8 inch lifts, each lift compacted at or above 95 percent maximum Modified Proctor density. Within a 1V:1H zone up from bottom of wall, perform compaction with hand-operated equipment.

B. Backfill excavated areas under lawns or improved areas to topsoil subgrade with structural fill. Place backfill from top of underdrain system to topsoil subgrade in maximum 12 inch lifts, each lift compacted at or above 92 percent maximum Modified Proctor density.

C. Employ placement and compaction methods that do not disturb or damage adjacent work.

D. Maintain moisture content of backfill material to within ±2 percent of optimum to attain required compaction density.

E. Do not backfill with frozen material or where the material already in the excavation is frozen.

F. Remove from site all excess excavated materials and dispose of material in compliance with all local, state and federal regulations.

3.14 BACKFILLING BUILDING FOUNDATION STRUCTURES

A. Excavations where exterior finish grade exceeds interior floor elevation or where building foundation walls act as basement walls or retaining walls shall be backfilled with structural fill. Confirm completion of waterproofing and underdrain system prior to placing backfill material. Confirm concrete structure has attained full retaining strength prior to placing backfill material. Refer to structural drawings for construction sequence, temporary bracing of the foundation walls and other pertaining information prior to backfilling. Place backfill from top of underdrain system to subgrade of pavements or topsoil subgrade in maximum 8 inch lifts, each lift compacted at 95 percent maximum Modified Proctor density. Protect, do not disturb underdrain system or waterproofing.

B. Excavations where exterior finish grade is at or below interior floor elevation shall be backfilled with structural fill under pavements and select fill under landscape areas. Confirm completion of waterproofing and underdrain system prior to placing backfill material, where applicable. Place structural fill from top of underdrain system or bottom of excavation to subgrade of pavements in maximum 8 inch lifts, each lift compacted at 95 percent maximum Modified Proctor density. Place select fill from top of underdrain system or bottom of excavation to subgrade of topsoil in maximum 8 inch lifts, each lift compacted at 90 percent maximum Modified Proctor density. Protect, do not disturb underdrain system or waterproofing.

C. Employ placement and compaction methods that do not disturb or damage adjacent work.

D. Maintain optimum moisture content of backfill material to attain required compaction density.

E. Do not backfill with frozen material or where the material already in the excavation is frozen.

3.15 SUBSURFACE DRAINAGE

A. Subdrainage Pipe: Specified in Section 334000 "Storm Sewerage."

B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch (150-mm) course of drainage stone on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches (300 mm) of drainage stone, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches (150 mm).
   1. Compact each drainage stone layer with a minimum of two passes of a plate-type vibratory compactor before covering with geotextile.

C. Drainage Backfill: Place and compact drainage stone over subsurface drain, in width indicated, to within 12 inches (300 mm) of final subgrade, in compacted layers 6 inches (150 mm) thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches (150 mm).
   1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698 with a minimum of two passes of a plate-type vibratory compactor.
   2. Place and compact impervious fill over drainage backfill in 6-inch- (150-mm-) thick compacted layers to final subgrade.

3.16 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:
   1. Under grass and planted areas, use select fill.
   2. Under walks and pavements, use satisfactory soil or structural fill.
   3. Under steps and ramps, use structural fill.
   4. Under building slabs, use structural fill.
   5. Under footings and foundations, use structural fill.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

D. The degree of compaction is expressed as a percentage of the maximum dry density at optimum moisture content as determined by ASTM D1557, Method C. the compaction requirements in lawns and planting areas shall be as follows:

   1. Location Minimum Maximum

	Degree of Compaction	
Fills within lawn and planting areas to within 18-inches of finished subgrade.	82%	87%
Fills within lawn and planting areas in top 18-inches of finished grade.	85%	87%

3.17 EMBANKMENT FOR PROPOSED PAVEMENT SUBGRADE

A. Ground Surface Preparation: Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placement of fills. Plow, strip, or break up sloped surfaces steeper than one (1) vertical to four (4) horizontal so that fill material will bond with existing surface.
   1. When existing ground surface has a density less than that specified break up ground surface, pulverize, moisture condition to optimum moisture content, and compact to required depth and percentage of maximum density. Place embankment fill material in maximum 6 inch compacted lifts. Spread wet embankment fill in 8 inch loose lift and disc to expedite air drying. Remove rock particles larger than 4 inches.

B. Adjust moisture content of embankment fill material to within 2 percent of optimum by either air drying or addition of water prior to compaction.

C. Compact embankment fill with a smooth drum compactor weighing at least 30 tons and operating in the vibratory mode.

3.18 AGGREGATE COURSES FOR PAVEMENTS

A. Verify that subgrade has been compacted to specified density and tested prior to placing geotextile.

B. Place soil stabilization fabric on prepared subgrade in accordance with manufacturer's instructions. Remove rocks and other objectionable material that could puncture the fabric.

C. Maintain grades, elevations and cross-slopes of aggregate base courses for proposed pavements, as shown on the Drawings.

D. For proposed asphalt concrete pavements, construct base course to the compacted thickness shown on the Drawings with Type 2 subbase material.

E. For proposed portland cement concrete pavements, construct base course to the compacted thickness shown on the Drawings with Type 4 subbase material.

F. Place aggregate materials in layers of uniform thickness conforming to indicated cross-section and thickness. Maintain moisture content within $\pm$2 percent of optimum for compacting base course during placement.

G. Compact aggregate materials with a smooth drum compactor weighing at least 30 tons and operating in the vibratory mode. When a base course is more than 6 inches thick, place material in equal layers, except no single layer more than 6 inches or less than 3 inches in thickness when compacted.

H. Use mechanical tamping equipment in areas inaccessible to drum compactor.

I. Test roll aggregate base course with fully-loaded, ten-wheeled dump truck weighting at least 18 tons prior to placing asphalt concrete pavements.

3.19 COMPACTION

A. General: Control soil compaction during construction providing minimum percentage of density specified for each area classification indicated below.

B. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum dry density:
   1. Pavements: Compact top twelve (12) inches of subgrade and each layer of backfill or fill material to ninety-five (95) percent maximum Modified Proctor dry density, at +/- 2% of its optimum moisture content.

C. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade or layer or soil material, to prevent free water appearing on surface during or subsequent to compaction operations.
   1. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.
      a. Soil material that has been removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry. Assist drying by discing, harrowing or pulverizing until moisture content is reduced to within 2% of its optimum moisture content.

3.20 DISPOSAL OF UNSUITABLE AND EXCESS EXCAVATED MATERIAL

A. Load, remove, and dispose of all unsuitable and excess excavated material in compliance with all local, state and federal regulations. Cover all loads leaving the site and using public highways.

B. Construction debris, trash, and any other objectionable solid waste regulated by 6 NYCRR Part 360, will not be permitted to be buried on the project site.

3.21 TOLERANCES

A. Excavation for Utility Structures and Trenches: Within plus or minus 2 inches.

B. Top Surface of Backfilling: Within plus or minus 1 inch.

C. Top Surface of Aggregate Base Course: Within 1/2 inch. Cross-slope within 1/4 inch when measured with a 10 foot straightedge.

3.22 FIELD QUALITY CONTROL

A. Compaction testing of embankment fill, aggregate base course and backfill materials will be performed by Owner's Geotechnical Engineer in accordance with ASTM D1557, Modified Proctor.

B. If tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

C. Seal compacted fill surfaces at the end of each construction day. Slope grade such that surface water will not pond adjacent to original excavation.

D. Provide UL certificate for any repairs made to underground electric service damaged by Contractor operations.

3.23 PROTECTION

A. Protect excavations by methods required to prevent cave-in or loose soil from falling into excavation.

B. Protect bottom of excavations and soil adjacent to and beneath structures, from freezing.

C. Protect, support and maintain all underground and surface structures to remain and other obstructions encountered. Restore structures which may have been disturbed.

D. Encase all existing underground gas, electric, telephone, and cable utilities exposed during construction in cushion sand during backfilling of excavated areas.

E. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape and compact to required density prior to further construction.

F. Where settling is measurable or observable at excavated areas during warranty period, remove surface, add backfill material, compact and replace surface treatment.

End of Section

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Section 31 23 13

SUBGRADE PREPARATION IN PLANTING AREAS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Requirements set forth herein are in addition to and shall be considered as complementary to the Terms and Conditions for Construction and the balance of Divisions 00 and 01 and Technical Specifications.

B. All Contractors, Subcontractors, Vendors and the like shall be required to familiarize themselves with said provisions.

1.2 SUMMARY

A. Provide all labor, equipment, materials, incidental work, and construction methods necessary to decompact the subgrade in areas designated for new lawns and planting.

1.3 RELATED WORK UNDER OTHER SECTIONS

A. The following items of related work are specified and included in other Sections of the Specifications:

1. Division 01 Section Temporary Erosion & Sediment Control
2. Division 31 Section Earthwork
3. Section 329119 LANDSCAPE GRADING

1.4 REFERENCES

A. The following standards shall apply to the work of this Section.

1. Associated General Contractors of America, Inc. (AGC):
   a. Manual of Accident Prevention in Construction
2. American Society for Testing and Materials (ASTM):
   a. D 1556 Density of Soil In-Place by the Sand Cone Method
   b. D 2167 Density and Unit Weight of Soil In-Place by the Rubber Balloon Method
   c. D 2922 Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth)
   d. D 2937 Density of Soil In-Place by the Drive-Cylinder Method
   e. D 3017 Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
3. New York State Department of Transportation - Standard Specifications, Construction and Materials current edition.

1.5 QUALITY CONTROL TESTING REQUIREMENTS

A. Quality Control for Areas of Subsoiling and Decompaction:

1. Quality control shall be a 2 phase operation including 1) penetrometer testing of existing undisturbed soils and 2) penetrometer testing of areas of turf and planting after subsoiling operations have been completed.
2. Perform penetrometer tests on existing, undisturbed soils in accordance with the requirements of this Section.
3. Prior to the spreading planting soil mixes in designated areas, the Contractor shall demonstrate to Owner's Representative that the depth of subsoiling has been met in accordance with the requirements of this Section. Contractor shall verify level and depth of soil decompaction using a shovel and a penetrometer. In locations as directed by the Owner's Representative, dig holes 6-inches deep in the surface of the subsoil and test the bottom of the holes to depth of 6-inches with penetrometer, recording the dial gauge reading. Incrementally test the subsoil every three inches of increasing depth by shovel and penetrometer until the full specified thickness of subsoiling and decompaction has been verified. Record points where full depth subsoiling and decompaction have not been attained.
4. Repeat testing operation at representative locations of the construction site as determined by the Owner's Representative to verify specification requirements have been met.
5. In all areas where penetrometer testing shows specified depths of subsoiling have not been met, the Contractor shall perform remedial subsoiling to the specified depths.
6. Following the work of decompacting planting soil mixes and prior to any work of seeding, sodding or planting, test planting soil mixes and underlying subsoil with the penetrometer in locations as directed by the Owner's Representative.
7. In all areas where penetrometer testing shows the planting soil and underlying subsoil have not been decompacted, the Contractor shall perform remedial decompaction work.

1.6 DEFINITIONS

A. Soil compaction: the formation of dense layers of overly packed soil. Compaction will force soil particles closer together, driving out pore space and reducing the volume of air and water in soil. Compaction seals off the soil surface and reduces the amount of air and water that enters the soil. Compaction reduces and can eliminate the movement of water and air through the soil, preventing the movement of plant roots through the soil and creating anaerobic conditions that will kill plant material and turf.

B. Sub-grade: Existing native soil in cut, on-site borrow in fill conditions, or imported soils in fill conditions, all of which meet the requirements of this Specification, upon which planting soils or granular pavement base are placed shall be known as sub-grade.

C. Subsoiling: The vertical and lateral fracturing of compacted subsoil material to full depth of compaction through deep ripping and de-compaction to restore soil porosity and permeability, to aid in infiltration of water, and to promote root growth.

D. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within building lines.

1.7 COORDINATION

A. Prior to start of any subsoiling and decompaction work the Contractor shall arrange an on-site meeting with the Owner's Representative for the purpose of establishing

Contractor's schedule of operations and scheduling inspection procedures and requirements.

PART 2 - PRODUCTS

2.1 PENETROMETER

A. Provide one Static Cone Penetrometer for use on this project. Make Penetrometer available to the Owner's Representative for use during the on-site Pre-Installation Conference and as required during the course of the work of the Project.

B. Static Cone Penetrometer shall be a hydraulic measuring device designed and manufactured to measure soil compaction. It shall be a 2 handed, analogue dial read meter gauged to read up to 1000 PSI. Penetrometer shall be one of the following hand-held devices:

1. Hand Penetrometer, #06.01 by Eijkelkamp Agrisearch Equipment, PO Box 4. 6987 ZG Giesbeek, The Netherlands
2. Handsounding Static Penetrometer, Model HAS-5, by Rocktest T: 1-450-465-1113; www.roctest.com
3. H-4210A Portable Static Cone Penetrometer, by Humboldt Manufacturing Company, Schiller Park IL 1-800-544-7220: www.humboldtmfg.com
4. Hydraulic Penetrometer, Pike Agri-Lab Supplies, Inc.; Jay, Maine; 207- 897- 9267; www.pikeagri.com
5. Hand Penetrometer Kit, 1 Meter Mechanical Gauge Type, 0325KL1 by Soil Moisture Equipment Corp., Santa Barbara, CA; T-805-964-3525; www.soilmoisture.com

PART 3 - EXECUTION

3.1 EARTHWORK - GENERAL

A. Work defined as excavation and filling, rough grading, trenching and backfilling, stripping and stockpiling of topsoil and all other earthwork related construction activities shall be specified, performed, permitted and paid for under the work of Division 31 Sections of this Specification. Coordinate the work of this Section with work activities and schedules in those Sections.

B. Coordinate the schedule of penetrometer application with the work of Section 329119 LANDSCAPE GRADING.

3.2 SUBSOILING AND DECOMPACTION OF SOILS

A. General:

1. All in-place soil within the limit of work that has been subject to any foot or vehicular traffic, equipment storage or material stockpiling prior to the commencement of this Contract or during the performance of this Contract shall be subsoiled and decompacted to a depth of 24 inches in accordance with the requirements of this Specification.

B. Recording compaction levels of existing soils:

1. At the beginning of the construction project and in the presence of the Owner's Representative, locate areas of the property that have not been subject to loading and compaction. Locations of undisturbed soils are typically found on the edges of the property, in shrub beds or under trees. Using the penetrometer, determine the base-line level of soil compaction of undisturbed soils on site. In the event that the penetrometer probe encounters resistance or is prevented from penetrating the soil assume the probe has encounter a rock or other obstruction. Perform no less than 12 penetrometer tests on existing, undisturbed soils to determine compaction levels of existing soil. Prepare a chart of findings noting PSI by location and present to the Owner's Representative for review and approval.

C. Subsoiling Operations:

1. Vertically and laterally fracture all exposed subsoil material within the Limits of Work through deep ripping and decompaction, restoring soil porosity and permeability and aiding infiltration and reducing runoff. Restrict fracturing of subsoil to those areas of turf and planting. Fracture the subsoil to a depth of 24 inches.
2. Effective fracturing of compressed subsoil material is achieved only when the soil material is moderately dry to moderately moist. Perform subsoiling only when soil has suitable moisture content as described in this Specification.
3. In the presence of the Owner's Representative determine subsoil moisture content. The Contractor shall auger a hole to a depth of 24 inches below the surface of the subsoil. Reach in and extract a handful of soil.
4. Hand roll the sample between the palms down to a 1/8-inch diameter snake. If the soil sample crumbles apart in segments no greater than 3/8 of an inch long when it is rolled down to 1/8 inch diameter, it is low enough in moisture for deep ripping. Conversely, if the rolled sample stretch out in increments greater than 3/8-inch before crumbling, it is in a plastic state of soil consistency and is too wet for sub-soiling and final decompaction.

D. Subsoiling and Decompaction:

1. Subsoiling and decompaction shall be performed in a two-phase process.
2. Subsoiling shall be accomplished by deep ripping or bucket excavation as follows:

E. Subsoiling Large Areas by Deep Ripping:

1. Deep rip the affected areas of exposed subsoil material, aggressively fracturing it before the planting soil is spread. Use a "heavy duty" agricultural-grade, deep ripper for this first phase of deep ripping. Rip the subsoil to the full depth of compaction.
2. Use the following rule of thumb for tractor horsepower (hp) whenever deep ripping and decompacting: Have at least 40 hp of tractor pull available for each mounted shank/ leg of the ripper. For example, a 3-shank ripping implement shall be pulled by a tractor with a 120 hp engine. A 5-shank implement shall be pulled by a 200 hp tractor.
3. Deep ripping shall be performed in three passes across the compacted subsoil. The first and second passes shall consist of parallel, forward- and-return runs, with each progressive pass of the implement's legs or shanks evenly staggered between those from the previous pass, ensuring vertical fracturing on 12 to 15 inch

centers. A final pass shall be performed at a 45 to 60 degree angle to the previous two passes.

4. Final depth of deep ripping of this first phase shall be achieved to a depth of 24 inches, to which end the ripping implement shall be modified as required.
5. The operating speed for pulling the deep ripper through the soil shall not exceed 3 mile per hour, a rate of operating speed slow that will ensure maximum functional performance of soil fracturing.
6. Do not use industrial-grade variations of ripping implements that are attached to power graders or bulldozers. The shanks and teeth of these rippers are often too short and stout and are mounted too far apart to properly restore soil permeability and infiltration.
7. Any oversize rocks which are uplifted to the subsoil surface during the deep ripping phase shall be collected and removed.

F. Sub-soiling Areas by Bucket Excavation:

1. Excavate the area of compacted areas to turn over and fracture the subsoil material before the planting soil is spread. Use backhoe or excavator for this first phase of sub-soiling.
2. Plan out and execute sub-soiling by bucket excavation in a manner such that the excavation equipment backs out of the area of compacted subsoil without traversing sub-soiled areas with equipment.
3. Final depth of bucket excavation of this first phase shall be 24 inches. Perform all excavation in the presence of the Owner's Representative.
4. Any oversize rocks which are uplifted to the subsoil surface during the excavation phase shall be picked up and removed by hand.

G. Decompaction of Planting Soil:

1. In the course of spreading the planting soil avoid compaction of the previously ripped subsoil. Avoid compaction of the planting soil. The second phase of the operations shall be evaluation of the planting soil by penetrometer. De-compact overly compacted planting soil as noted in this Section. This second phase of de-compaction mitigates the partial re-compaction which occurs during the heavy process of planting soil spreading and grading.
2. Prior to deep ripping and de-compacting the site, all construction activity, including access by construction equipment, material storage, site cleanup and trafficking shall be completed and the site closed off to further disturbance. In the event of the operations of deep ripping and de-compaction are interrupted by rain, proceed no further until the subsoil has dried and the palmed roll crumbles in accordance with the requirements of this Section.

3.3 COMPACTION

A. Compaction of areas where subgrade has been decompacted shall be performed as specified under the work of Section 329119 LANDSCAPE GRADING. Particular attention shall be given to requirements for tracked or LGP vehicles.

3.4 PROTECTION

A. Protecting Graded Areas: Protect newly decompacted and sub-graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and re-establish subgrades to the specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

C. Where settling occurs before acceptance of finished grade, remove finished surfacing or planting soil, backfill with additional soil material, recompact and reconstruct surfacing, planting soil and install new plant material or turf as directed by the Approved Soil Scientist.

D. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.5 CLEANUP

A. At the end of all earthwork and rough grading operations and before acceptance of the work, the Contractor shall remove all debris, rubbish, garbage, trash, and discarded material, from the site. He shall dispose of them in a manner satisfactory to the Owner's Representative. The premises shall be left clean, presentable, and satisfactory.

END OF SECTION

Section 32 12 16

HOT MIX ASPHALT (HMA) PAVEMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Asphalt pavements on the main campus are to be surfaced with Hot Mix Asphalt (HMA) concrete. Paved surfaces in low use areas off-campus may be of oil and stone penetration for light or medium duty service upon approval by Cornell University's Department of Facilities Engineering.

B. Pavement Sections:

1. In general, Heavy Duty HMA Pavements shall be designed for areas where heavy traffic volumes occur or trucks/mass transit vehicles operate. See Cornell Standard Detail 1.4.2.

2. Medium Duty HMA Pavements shall be designed where traffic is moderate and is limited to passenger vehicles. See Cornell Standard Detail 1.4.1.

3. Light Duty HMA Pavement shall be designed in limited circumstances where no vehicle traffic is expected or in temporary situations when approved by the University.

4. Pavement can be designed such that a combination of pavement sections are used in parking facilities where heavy duty is used on travel lanes, and medium duty is used in parking stalls. In all cases, the design professional shall consider cost impacts to the project and constructability when specifying varying pavement sections.

5. All pavements shall be designed with a suitable subbase course.

   a. Subbase specified in roadways shall consist of a crushed ledge rock meeting the requirements of NYSDOT Type 2 Subbase.
   b. Pavements in low use areas, or under sidewalks may use subbase consisting of crushed gravel meeting the requirements of NYSDOT Type 4 Subbase.
   c. If the use of millings is specified by the design professional, the material shall be of consistent quality and gradation and be less than 2" in size in any dimension. The use of millings, if permitted, shall be limited to materials from Cornell projects, and its placement shall be limited to the bottom 3" of the subbase course it is designed to replace.

1.02 REFERENCE

A. Cornell University has adopted New York State Department of Transportation (NYSDOT) Standard Specifications Section 402 – Hot Mix Asphalt (HMA) Pavements. The materials in the section are also referred to as Superpave Mixes.

1. That NYSDOT Standard Specification current at the time of letting shall be

considered as the applicable version in force for the project.

2 Reference to the "Department" shall refer to Cornell University

1.02 SUBMITTALS

A. Contractors shall provide a copy of Job Mix Formula (JMF) from a NYSDOT approved plant, signed by the Regional Materials Engineer with the date of signature no more than two years old. Substitutions or cross outs on the signed JMF will not be accepted.

B. Contractors shall provide a Plant Certification for each day's placement, certifying that all materials are in accordance with NYSDOT Standards and a total of each mix type delivered to the jobsite under that contract.

PART 2 PRODUCTS

2.01 HMA MIXTURES

A. Shall be in accordance with NYSDOT Standard Specification 402-2 Materials with the following exceptions and notations.

B. Mix Types – The following General Mix Types shall be used on Cornell projects:

1.	Asphalt Base Course:	25mm Binder HMA	NYSDOT ITEM# 402.257903*
2.	Asphalt Binder:	19mm Binder HMA	NYSDOT ITEM# 402.197903*
3.	Asphalt Top Course:	9.5mm Top HMA	NYSDOT ITEM# 402.097203*

*Last digit in Item # refers to NYSDOT Revision #. Provide most current Revision.

4. Designer may specify other mixes as required (Thicker Base Courses, Shims, etc.) however all mixes shall meet the requirements of NYSDOT Section 402.

C. Performance Graded (PG) Binder (Information to be included in Bid Documents)

1. Use a PG 64S-22 meeting the requirements of AASHTO M320, Standard Specification for Performance Graded Asphalt Binder for the production of Superpave Hot Mix Asphalt mixtures for this project.

2. Use of polyphosphoric acid (PPA) to modify the PG binder properties is prohibited. This prohibition also applies to the use of PPA as a cross-linking agent for polymer modification.

3. The mixture designs must be developed in accordance with the criteria specified in the SUPERPAVE Hot Mix Asphalt items that are appropriate for an estimated traffic level of <30 Million 80 kN ESALs.

2.02 TACK COAT

A. Shall be used in accordance with NYSDOT Section 402 and meet the requirements of Section 407. Refer to Appendix 1 – Basis of Design.

2.03 ASPHALT JOINT ADHESIVE

A. Shall be used in accordance with NYSDOT Section 402 and meet the requirements of NYSDOT Standard Specification Section 418. Refer to Appendix 1 – Basis of Design.

PART 3 EXECUTION

3.01 Asphalt Mixtures shall be in accordance with NYSDOT Standard Specification 402-3 with the following exceptions and notations.

A. Cornell will provide Third Party acceptance testing for the pavement density testing by nuclear density gauge. Contractors are encouraged to have their own trained and certified technicians to assure quality and to verify Third Party results.

B. Pavement Density will be verified and accepted by the 70 Series Compaction Methods with all acceptance testing by the Cornell University Third Party Technician. Cornell reserves the right to take pavement cores to test for density in accordance with this section. Contractors shall work with the University to assure that the requirements of the section are carried out with full cooperation of the paving contractor and or subcontractor.

APPENDIX 1 – BASIS OF DESIGN
CORNELL UNIVERSITY - HOT MIX ASPHALT & TACK COAT

General Name	NYSDOT Marshall Mix Name	NYSDOT Current Name	NYSDOT Item #					Min. Thick.	Max. Thick.
				Compaction Series	Friction	QA Method	Revision *		
Base	Type 3 Binder	25 mm Binder (**Base**) Course	**402.25**	**7**	**9**	**0**	**3**	2.5”	4”
Binder	Baby Binder	19 mm **Binde**r Course	**402.19**	**7**	**9**	**0**	**3**	2”	3”
Top - Option	Type 6 Top	12.5 mm Top Course	**402.12**	**7**	**2**	**0**	**3**	1.5”	2”
Top - Preferred	Type 7 Top	9.5 mm **Top** Course	**402.09**	**7**	**2**	**0**	**3**	1.5”	2”

Designer Notes:
Asphalt Items shall meet the current version of the NYSDOT Standard Specifications (NYSDOT SS), Section 402, based on Letting Date. 25 mm Binder Shall be Standard Base Course.
19 mm Binder Shall be Standard for Binder
9.5 mm Top Shall be Standard Roads and Parking Lots (12.5 mm available as an option)
Testing Method shall be by use of Nuclear Gauge with all testing by Owner (Other Methods May be Specified including 5-Cores, 6-Nuke Gauge/Cores, 7- Nuclear Gauge, 8-Rolling Pattern)
QA Method refers to any pay adjustment factor (not applicable = 0)
* Revision # Refers to Latest Version of the NYSDOT Standard Specifications, Currently Revision 03 (Projects Let after Jan 2018)

Asphalt Joint Adhesives
Asphalt Pavement Joint Adhesive shall be used on all transverse and longitudinal joints for Top Course in accordance with NYSDOT SS Item # 418.7603

Tack Coat
Tack Coat shall be used as outlined below and be in accordance with NYSDOT SS (Latest Editions) Section 407.
Tack Coat shall be placed between lifts of newly hot mix asphalt, on milled surfaces.

Surface	Application Rate Diluted	Application Rate Straight
New Hot Mix Asphalt (HMA) Paving	.05-.06 gal/sy	.03-.04 gal/sy
Milled and Existing HMA & Portland Cement Concrete	.08-.10 gal/sy	.05-.06 gal/sy

APPENDIX 1 – BASIS OF DESIGN
CORNELL UNIVERSITY - HOT MIX ASPHALT & TACK COAT

SPECIAL NOTE PG BINDER AND MIX DESIGN LEVEL

PG Binder

Use a PG 64S-22 meeting the requirements of AASHTO M320, Standard Specification for Performance Graded Asphalt Binder for the production of Superpave Hot Mix Asphalt mixtures for this project.

Use of polyphosphoric acid (PPA) to modify the PG binder properties is prohibited. This prohibition also applies to the use of PPA as a cross- linking agent for polymer modification.

The mixture designs must be developed in accordance with the criteria specified in the SUPERPAVE Hot Mix Asphalt items that are appropriate for an estimated traffic level of <30 Million 80 kN ESALs.

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Section 32 13 13

REINFORCED CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Requirements set forth herein are in addition to and shall be considered as complementary to the Terms and Conditions for Construction and the balance of Divisions 00 and 01 and Technical Specifications.

B. All Contractors, Subcontractors, Vendors and the like shall be required to familiarize themselves with said provisions.

1.2 SUMMARY

A. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to furnish and install reinforced concrete pavement, as indicated on the Contract Documents and as specified herein.

1. Finished concrete pavement.
2. Concrete base slabs for unit paving.
3. Miscellaneous slabs and bases as indicated.

1.3 RELATED WORK UNDER OTHER SECTIONS

A. The following items of related work are specified and included in other Sections of the Specifications:

1. Section 079001 SEALANT JOINTS - SITE
2. Section 311000 EARTHWORK
3. Section 312500 EROSION AND SEDIMENT CONTROL
4. Section 321640 STONE CURB
5. Section 321440 STONE UNIT PAVING MUD SET, base under pavers.

1.4 REFERENCES

A. The following standards shall apply to the work of this Section.

1. American Concrete Institute (ACI):
   a. 302.1R Guide for Concrete Floor and Slab Construction.
   b. 305R Hot Weather Concreting.
   c. 306R Cold Weather Concreting.
   d. 308R Standard Practice for Curing Concrete.
   e. 309R Standard Practice for Consolidation of Concrete.
   f. 316R Recommendations for Construction of Concrete Pavements and Concrete Bases.
   g. 318 Building Code Requirements for Reinforced Concrete.
   h. 347 Recommended Practice for Concrete Formwork.
2. American Society for Testing and Materials (ASTM):

a. A 185 Specification for Steel Welded Wire Fabric. Plain, for Concrete Reinforcement
b. A 615 Specification for Deformed and Plain Billet - Steel Bars for Concrete Reinforcement
c. C 33 Specifications for Concrete Aggregates
d. C 94 Specifications for Ready-Mixed Concrete
e. C 143 Test Method for Slump of Hydraulic Cement Concrete
f. C 150 Specification for Portland Cement
g. C 171 Specification for Sheet Materials for Curing Concrete
h. C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
i. C 309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
j. C 494 Specification for Chemical Admixtures for Concrete
k. C 1116 Standard Specification for Fiber Reinforced Concrete & Shotcrete
l. D 226 Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
m. C260 Air-Entraining Admixtures for Concrete.
n. C494 Chemical Admixtures for Concrete.
o. D 545 Test Methods for Preformed Expansion Joint Fillers for Concrete Construction (Nonextruding and Resilient Types)
p. D 1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort [56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)]
q. D 1752 Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

3. New York State Department of Transportation - Standard Specifications, Construction and Materials current edition.

1.5 SUBMITTALS

A. Concrete mix design for each type of concrete. The Contractor shall warrant by the submission of the design mixes that such mixes are totally representative of the concrete that he intends to supply to meet the requirements of the Contract Documents. Submit new design mixes for review and approval when any change in materials is required or needed. Include the following information for each concrete mix design:

1. Mix identification designation (unique for each mix submitted).
2. Statement of intended use for mix.
3. Compressive Strength at Seven and Twenty-Eight Days: Submit strength test records, mix design materials, conditions, and proportions for concrete used for record of tests, standard deviation calculation, and determination of required average compressive strength. The submission shall be in accordance with ACI 318.
4. Gradation of Fine and Coarse Aggregates: Testing data confirming proposed coarse aggregate meets ASTM C33 class designation. Include ASTM test results for aggregates subject to freeze-thaw environment.
5. Proportions of all ingredients, including all admixtures to be added either at the time of batching or at the jobsite.

6. Water-to-cementitious-materials ratio.
7. Slump tested in accordance with ASTM C143.
8. Air content of freshly mixed concrete by the pressure method, ASTM C231, or the volumetric method, ASTM C173.
9. Unit Weight of Concrete: ASTM C138.
10. Written certifications of the following:
    a. Mill test reports of portland cement chemical and physical analysis and certification of compliance with ASTM C150 Type I/II.
    b. Mill test reports of fly ash chemical and physical analysis and certification of compliance with ASTM C618 Class C or F, if used.
    c. Mill test reports of slag chemical and physical analysis and certification of compliance with ASTM C989, if used.
11. Manufacturer's Spec Data Sheets of each concrete admixture, including brand name, manufacturer, and dosage rate range.
12. Written certification of aggregate compliance with ASTM C33, including all restrictions on reactive materials, with the additional provision that the effectiveness of the use of a cement with less than 0.60% alkalis (sodium-oxide equivalent) or other mitigation methods shall be demonstrated by ASTM C1260, ASTM C1567, and/or ASTM C1293 testing or the aggregate shall have a demonstrated satisfactory performance history prior to acceptance.

B. Submit manufacturer's product data for the following:

1. Form release agent.
2. Preformed joint filler.
3. Sealants.
4. Macro Fiber Reinforcement.
5. Curing Materials.
6. Surface Sealant.

C. Submit samples of the following:

1. Color chart for selection of joint sealant color.
2. Provide 5-pound sample of coarse aggregate used for concrete pavement, for review and approval by the Resident Engineer.

D. Construct Concrete Sample Panels:

1. Construct 8-foot x 8-foot sample panels of finished concrete pavement to thickness specified on the Drawings, for approval, at least 15 days prior to final concrete paving work. Samples shall be constructed within the vicinity of the proposed finish work to facilitate comparisons during construction. The samples shall demonstrate the typical installation of concrete, including score lines, expansion joint and sealant, curing and finishing material, surface texture, color, and edge treatment.
2. The mockup(s) shall be constructed in the same manner as intended for the remaining work. The Resident Engineer will observe the prepared surfaces, reinforcement, and installation of the new paving concrete slabs and review the color, finish and texture of the mockup(s).

3. The accepted sample, upon approval, shall be maintained as the standard of minimal quality for approval of all proposed concrete pavement work required for the project.
4. If the original sample panel is not approved, the Contractor shall provide additional sample panels, as required, at no additional cost to the Cemetery until an approved sample is obtained.
5. Unacceptable sample panels shall immediately be removed from the site.
6. The approved sample panel may become a permanent installation of pavement if approved by the Resident Engineer.

1.6 PRE-INSTALLATION CONFERENCE

A. Pre-installation Conference:

1. Schedule a meeting with the concrete paving installer, General Contractor, Resident Engineer and the Cemetery at a time sufficiently in advance of paving installation to permit coordination.
2. At the meeting review paving system quality control requirements including details of construction, outstanding submittals, Drawings and Specifications, and on site conditions affecting or which may affect installations.
3. Contractor shall record discussions, including agreements or disagreements on matters of quality control. General Contractor shall furnish copies of recorded discussions to each participant within 3 working days of the meeting.

1.7 QUALITY ASSURANCE

A. Reinforced Portland cement concrete paving shall conform to ACI 316R, and applicable portions of the following:

1. New York State Department of Transportation - Standard Specifications, Construction and Materials current edition.

B. Surfaces of curb ramps and handicapped access ramps shall be stable, firm and slip resistant. Construct ramps so that water does not accumulate on ramp surfaces.

C. If damaged or removed during course of this project, existing pavement areas shall be repaired or replaced under this Section.

PART 2 - PRODUCTS

2.1 AGGREGATE BASE COURSE

A. Base course shall be specified, provided, installed and paid for under the work of Section 31 20 00 EARTHWORK.

2.2 PLASTIC SHEET FOR SLABS ON GRADE

A. Polyethylene sheeting in accordance with the requirements of ASTM E1745-11 Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs.

1. Provide Class A sheeting
2. 15-mils thickness with a perm rating of less than 0.01.
3. Sheeting shall be manufactured form 100-percent virgin resins.
4. Sheeting shall meet the following requirements

TECHNICAL DATA

Properties	15-mil
Water Vapor Permeance	
ASTM E96 Perms	0.0063
Puncture Resistance ASTM D 1709 Method B Grams	>3200
Tensile Strength ASTM E 154 Section 9 Lb. Force/Inch (kN/m)	72 (12.61)
Water Vapor Permeance After Wetting Out Drying Out and After Long-Term Soaking ASTM E-154 Section 8 ASTM E-96 Procedure B Perms	0.0052
Water Vapor Permeance Resistance to Plastic Flow and Elevated Temperature ASTM E-154 Section 11 ASTM E-96 Procedure B Perms	0.0057
Water Vapor Permeance Effect Low Temperature and Flexibility ASTM E-154, Section 12 ASTM E-96, Procedure B Perms	0.0052
Water Vapor Permeance Resistance to Deterioration From Organisms and Substances in Contacting Soil ASTM E-154, Section 13 ASTM E-96 Procedure B Perms	0.0052
Radon Transmittance (m/s) k124/02/95	8.7×10^{-9}
Radon Coefficient (m2/s)	3.3×10^{-12}

2.3 CONCRETE FORMWORK

A. The dimensions of the lumber used to form concrete pavements shall not be less than 2 inches nominal thickness by the required pavement depth shown on the Drawings.

2.4 FIBER REINFORCEMENT

A. Fiber Concrete Reinforcement: Polypropylene fiber reinforcement shall have 100 percent virgin fillbrated or monofiliment polypropylene fiber additives engineered and designed for use in concrete pavement, complying with ASTM C1116, Type III, ranging from 1/2-inch to one-inch lengths.

B. Fibers shall be added at the batch plant using standard mixing practices as specified by ASTM C94.

C. Install fibers in strict accordance with the manufacturer's recommendations.

D. Fibers shall have the following characteristics:

1.	Specific Gravity	0.91
2.	Absorption	None
3.	Tensile Strength	70-110 ksi
4.	Modulus of Elasticity	500 ksi
5.	Melt Point	160 degrees C
6.	Ignition Point	590 degrees C

2.5 CONCRETE MATERIALS

A. Portland cement: ASTM Specification C150, Type I/II, Grey or White, of same type, brand, and source. Use only one brand of cement for each type of cement throughout project. No visual variations in color shall result in exposed concrete.

B. Fly Ash: ASTM C618, Class F.

C. Slag: ASTM C989, Grade 100 or 120.

D. Normal-Weight Aggregates:

1. Sand shall consist of washed, clean, hard, uniformly graded natural silica sand in accordance with ASTM C33.
2. Coarse aggregate shall be nominal 3/4 inch maximum size, with distribution per ASTM C33, Table II, clean, and well graded.
3. All aggregate shall be certified by the supplier as being nonreactive in accordance with ASTM C1260, ASTM C1567, and/or ASTM C1293 or shall have a demonstrated satisfactory performance history.

E. Water: Clean, potable water, free of contaminants and in conformance with the requirements of ASTM C94.

F. Admixtures: Provide admixtures that are certified by the manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete, with written documentation. Do not use calcium chloride or admixtures containing calcium chloride. All admixtures must be approved in writing by the Resident Engineer prior to use. Manufacturer(s) approval for the use of all admixtures in combination must be submitted to the Resident Engineer prior to use.

2.6 ADMIXTURES

A. Admixtures shall be compatible with one another and with aggregates, cement, finishing materials, and other materials which may be affected thereby. Use of chemical admixtures manufactured by one company is recommended.

B. The use of calcium chloride or any admixture which contains calcium chloride or other chloride based ingredients shall NOT be permitted.

1. Air-entraining admixture: shall comply with ANSI/ASTM C 260.
2. Silica fume admixture: shall be supplied in slurry form as one of the following and in strict accordance with manufacturer's instructions; use water-fog misting or evaporation retarder immediately after floating flatwork containing silica fume:
3. Evaporation retarder: use water-based monomolecular film; use one of the following with flatwork containing corrosion inhibiter or silica fume admixture:
4. Water-reducing admixture: Shall comply with ANSI/ASTM C494, Type A and contain no more than .05% chloride ions.
5. Mid-range water-reducing admixture: ASTM C494, Type A. Subject to compliance with requirements, provide one of the following:
6. High-Range Water Reducing (HRWR) admixture (Super Plasticizer): shall comply with ASTM C494, Type F or Type G and contain not more than 0.05% chloride ions:
7. Accelerator admixture: Non-chloride and non-corrosive accelerators shall conform to ASTM C494 Type C and may be used when temperatures are below 50 degrees F.
8. Water-reducing Set Retarders: shall conform to ASTM C494 Type D and may be used when ambient temperatures exceed 80 degrees F.
9. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.
10. Shrinkage-Reducing Admixture: ASTM C494, Type S, such as the following:
11. Corrosion Inhibitor admixture: calcium nitrite based inhibitor shall comply with AASHTO M194 Type C

2.7 MIX PROPORTIONS

A. Design mix for all concrete paving shall conform to the following properties as indicated on Drawings and schedules:

1. Total Cementitious Content: 725 lbs/cu yd, maximum.
   a. If a low-alkali cement is used to address potential aggregate reactivity, its effectiveness shall be demonstrated by testing according to ASTM C1567.
   b. Limit use of fly ash in concrete exposed to deicing chemicals in service to not exceed 25% of cement content by weight. If fly ash contents above 25%

are required for reactive aggregate mitigation, provide ASTM C666 testing results indicating satisfactory performance.

c. Limit use of slag in concrete exposed to deicing chemicals in service to not exceed 25% of cement content by weight. If fly ash contents above 25% are required for reactive aggregate mitigation, provide ASTM C666 and ASTM C672 testing results indicating satisfactory performance.

2. Limit water-soluble, chloride-ion content in hardened concrete to 0.15% by weight of cement.
3. Twenty-Eight-Day Design Compressive Strength: 5,000 psi.
4. Air Content: Total 6-1/2% with a tolerance of ± 1-1/2% (5% to 8%) based on 3/4 inch maximum-sized aggregate. If another coarse-aggregate size is used, the air content will need to be adjusted to meet minimum air contents as identified in ACI 318 for severe exposure.
5. Slump Limits: 5 to 7 in.
6. Water to Cementitious Materials Ratio: W/CM shall be 0.40 or less.
7. Corrosion Inhibitor: The concrete shall contain a dosage of 1.0 gal/cu yd of corrosion inhibitor.
8. Do not use calcium chloride.
9. Use accelerating admixtures in cold weather only when approved by the Resident Engineer. Use of admixtures will not relax cold-weather placement requirements.
10. Use set-retarding admixtures during hot weather only when approved by the Resident Engineer.

B. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94/C94M and ASTM C1116/C1116M, and furnish batch ticket information.

1. When air temperature is between 85-degrees and 90-degrees Fahrenheit, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90-degrees Fahrenheit, reduce mixing and delivery time to 60 minutes.
2. Provide a batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added. Record approximate location of final deposit in structure.

2.8 CURING MATERIALS

A. Curing Compound:

1. Dissipating resin type with fugitive dye for use on surfaces to be painted, coated or have adhesive applied where incompatibility with the non-dissipating resin type compound exists:
   a. “V-Seal 102 Winter Guard” by V-Seal Concrete Sealers and Specialty Coatings.
   b. "Kurez DR" by the Euclid Chemical Company.
   c. "Curing Compound #2 DR" by the Anti Hydro Company.
   d. No substitutions.
2. Non-dissipating resin type with fugitive dye for all other vertical and horizontal surfaces:
   a. "Eucosil" by the Euclid Chemical Company.
   b. "Acuricon D" by the Anti Hydro Company.

c. "Super Kurhard 309" by A.H. Harris and Sons, Inc.
d. No substitutions.

B. Polyethylene Film: ASTM D 2103 and ASTM C 171, 4-mil thick, white color.

C. Waterproof Paper: ASTM C 171.

2.9 CONSTRUCTION JOINTS

A. Transverse construction joints shall be placed whenever installation of concrete is suspended for more than 30 minutes.

1. Butt joint with dowels or thickened edge joint shall be used if construction joints occur at location of control joint. Submit sketch to Resident Engineer for review and acceptance of proposed system.

2. Keyed joints with tiebars shall be used if the joint occurs at any other location.

2.10 BOND BREAKER

A. Bond breaker shall be asphalt felt conforming to ASTM D226, Type I or 6 mil polyethylene sheeting.

2.11 WATER REPELLENT PENETRATING SEALER

A. Provide a one part, low viscosity, reactive impregnation sealer designed specifically for concrete and cementitious substrates meeting the following requirements:

1. Chemical base shall be Alkoxysilane
2. NCHRP Report 224 Series II 125 Ft^2/gal.
   a. Water weight gain 85%
   b. Absorbed Chloride 96%
3. NCHRP 224 Series IV 125 Ft^2/gal
   a. Absorbed Chloride 79.1%
4. Freeze Thaw De-Icing Salt Resistance –
   a. 90 day salt ponding per AASHT) T259
   b. 0.0 – 0.5” 93%
   c. 0.5 – 1.0” 73%
   d. 1.0 – 1.5” 74%
5. Scaling Resistance None per ASTM C672
6. Penetration Depth <10 mm per OHD L-34

B. Sealer shall be Sikagard – 740 W as manufactured by Sika Corporation, Lyndhurst, NJ.

2.12 DETECTABLE WARNING PAVERS

A. Provide detectable warning surfaces on concrete unit pavers which comply with the detectable warnings on walking surfaces section of the Americans with Disabilities Act (Title 49 CFR TRANSPORTATION, Part 37.9 STANDARDS FOR ACCESSIBLE TRANSPORTATION

FACILITIES, Appendix A, Section 4.29.2 DETECTABLE WARNINGS ON WALKING SURFACES).

B. Concrete unit pavers with detectable warning surface shall comply with all aforementioned requirements for concrete unit pavers.

C. Concrete pavers shall conform to ASTM C936-82, Standard Specifications for Solid Concrete Interlocking Paving Units. The minimum compressive strength shall not be less than 7,200 pounds per square inch with the average compressive strength not less than 8,000 pounds per square inch Maximum absorption shall be 5 percent or less at 50 cycles of freeze-thaw testing per section ASTM C67. Submit paver tests for freeze thaw and abrasion resistance to be approved by the Architect.

1. Paver size shall be 24 inch square with beveled top edges.
2. Paver thickness shall be 2 inches.
3. Width and thickness shall not vary by greater than 1/16 inch.
4. Pavers shall have one 1/16 inch spacer on all 4 sides.
5. The finish shall be non-slip texture.
6. Paver color shall be ‘Charcoal’ from manufacturer’s standard color range which provides a 60% color contrast from the abutting concrete ramp pavement color, as required by the Americans with Disabilities Act.

D. Pavers shall be set over latex modified mortar bed with latex modified mortar joints.

PART 3 - EXECUTION

3.1 PREPARATION OF SUBGRADE

A. Areas to be paved shall be compacted and brought to subgrade elevation and all said work specified, performed and paid under Division 31 Sections related to EARTHWORK, before work of this Section is performed. Final fine grading, filling, and compaction of areas to receive paving, as required to form a firm, uniform, accurate, and unyielding subgrade at required elevations and to required lines, shall be as specified, performed and paid under Section 311000 EARTHWORK.

3.2 AGGREGATE BASE COURSE

A. Aggregate base course for concrete paving shall be provided, installed and paid for under this Section 311000 EARTHWORK.

3.3 FORMWORK

A. All forms shall be joined neatly and tightly, shall be set true to line and grade, well staked and braced, and shall have uniform bearing throughout their length. Remove all forms and miscellaneous appurtenances from pavement edges and dispose of all formwork and appurtenances at the end of the construction project.

1. Forms shall not be moved for 72 hours after the concrete has been placed, or for a longer period if directed by the Resident Engineer.
2. Remove all forms. Extreme care shall be taken in removing forms in order that no damage will be done to the concrete.
3. Under no condition shall any bar, pick or other tool be used which depends upon leverage on the concrete for removal of the forms.

B. Leave formwork pavement in place until concrete has achieved at least 80% of its twenty-eight-day design compressive strength.

3.4 PLASTIC SHEET INSTALLATION

A. Install plastic sheeting for the full extent of the concrete base slab directly over the compacted aggregate base.

B. Overlap edges a minimum of 6 inches and tape upper layer to lower layer to secure the plastic sheeting in place. Take care to prevent wind lift.

C. Protect sheeting from damage.

3.5 FIBER REINFORCEMENT

A. Fiber reinforcement: Polypropylene fiber reinforcement shall be added directly to the concrete mixing system at the rate of one and six-tenths pounds per cubic yard. Contractor shall perform all required concrete slump tests prior to adding fiber reinforcement. Contractor shall continue to mix concrete for a minimum of 5 minutes after adding polypropylene reinforcement.

3.6 EXPANSION JOINTS

A. Expansion joints shall be 1/2-inches wide and shall be as located on the Contract Documents. Form expansion joints in the concrete with preformed joint filler in place. Extend joint filler for the full depth of the slab and length of the expansion joint.

1. Set joint filler down 3/4-inch to create deep sealant recess below finished concrete surface to receive sealant.

B. Place expansion joints spaced on 20-foot centers.

1. Expansion joints shall be placed where pavement meets flush foundations and footings, or other vertical structures, including light bases, hydrants, walls, buildings, piers and walls, and at other conditions as shown on the Contract Documents.
2. Follow the manufacturer's application recommendations for joint filler and sealer.
3. Joint alignment shall be straight and true.

C. Where expansion dowels are use in the expansion joints, dowels and greased sleeves shall be set parallel with the top and bottom surfaces of the concrete slab.

D. Contraction Joints in Paving Slab: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth as shown on Drawings:

1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8 inch wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.
2. Contraction Joint Locations:
   a. Contraction joints in concrete paving slab shall be spaced at no more than 6-feet zero-inches on center, each way.

E. Isolation or Expansion Joints in Paving Slab: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.

F. Doweled Joints: Install dowel bars at joints where indicated. Where shown on Drawing, lubricate or sleeve one-half of dowel length to prevent concrete bonding to one side of joint.

3.7 PORTLAND CEMENT CONCRETE PAVING

A. Before placing concrete, verify that installation of plastic sheet and its laps and terminations are in place and intact.

B. Paving mix, equipment, methods of mixing and placing, and precautions to be observed as to weather, condition of base and the like, shall meet the requirements of ACI 316R. Pavement shall be constructed in accordance with the Contract Documents.

C. The Resident Engineer shall be notified of concrete placement sufficiently in advance of start of operation to allow his representative to complete preliminary inspection of the work, including subgrade, forms, and reinforcing steel, if used.

1. No concrete shall be deposited until the Resident Engineer has inspected the placing of reinforcement and given permission to place concrete.

D. Normal concrete placement procedures shall be followed. Concrete shall arrive at the job site so that no additional water will be required to produce the desired slump. When conditions develop that required addition of water to produce the desired slump, permission of the Resident Engineer must be obtained. The concrete shall be transported from the mixer to its place of deposit by a method that will prevent segregation or loss of material.

1. Concrete pavement shall be placed in a series of alternate pours such that every other panel bounded by expansion joints shall be poured first.
2. The intervening panels shall then be poured as a secondary operation only after the first panels have hardened sufficiently to allow the removal of all temporary transverse forming supports.
3. Concrete shall be placed in one course, to full depth, as detailed on the Contract Documents.

4. Ensure that plastic sheet on aggregate base and its laps and terminations remain intact during concrete placement and do not allow concrete to fill the drainage composite.

E. Work shall not be performed during rainy weather or when temperature is less than 40 degrees Fahrenheit In the event that unforeseen rain occurs, cover uncured concrete surfaces with plastic sheet covering to prevent alteration of texture. Concrete slabs with textured concrete surfaces altered by rain shall be removed from the site as directed by the Resident Engineer.

F. Adjacent work shall be protected from stain and damage during entire operation. Damaged and stained areas shall be replaced or repaired to equal their original conditions.

G. Existing concrete, earth, and other water-permeable material against which new concrete is to be placed shall thoroughly damp when concrete is placed. There shall be no free water on surface.

H. Concrete that has set or partially set before placing shall not be installed. Retempering of concrete will not be permitted. Remove and discard off site.

I. Concrete shall be thoroughly spaded and tamped to secure a solid and homogeneous mass, thoroughly worked around reinforcement and into corners of forms.

J. When joining fresh concrete-to-concrete that has attained full set, latter shall be cleaned of foreign matter, and mortar scum and laitance shall be removed by chipping and washing. Clean, roughened base surface shall be saturated with water, but shall have no free water on surface. A coat of 1:1 cement-sand grout, approximately 1/8-inch thick, shall be well scrubbed into thoroughly dampened concrete base. New concrete shall be placed immediately, before grout has dried or set.

3.8 DETECTABLE WARNING PAVER INSTALLATION

A. No pavers shall be laid in inclement weather or when the temperature is 36 degrees Fahrenheit, and dropping, nor shall any work be done on rising temperatures until the temperature reaches 32 degrees Fahrenheit. Frozen mortar materials shall not be used.

B. Concrete detectable warning pavers shall be set on a mortar setting bed over a prepared concrete base slab. All setting shall be done by competent workmen under adequate supervision. Do any cleaning necessary to cement concrete base to provide a clean base surface, free from dust, oil, grease, other impurities, or loose or friable particles.

C. Damp the surface immediately before placing the mortar setting bed, but do not allow free water to remain on the surface.

D. Latex modified mortar setting bed shall be spread evenly over moistened concrete base. Mortar setting bed shall be 1/2-inch thick, minimum. Back butter pavers with latex modified mortar to ensure a full bond between pavers and setting bed.

E. Before setting, the back of each piece of concrete paver shall be dampened. Each piece shall be carefully bedded into a wet, sticky mortar mixture and tapped home to a full and solid bearing. Particular care shall be exercised to equalize bed and joint openings and eliminate the need for redressing of exposed surfaces.

F. Exposed surfaces of pavers shall be kept free from bed mortar at all times. Any bed mortar smears shall be immediately removed with a clean sponge and clean water before latex modified mortar can set.

G. Pavers shall be set true to the required lines and grades in the pattern detailed on the Contract Documents.

3.9 FINISHING

A. Concrete flatwork surfaces shall be screeded off and hand floated and finished true to line and grade, and free of hollows and bumps. Surface shall be dense, smooth, and at exact level and slope required.

B. Finished concrete surface for subbases for unit pavement systems shall be wood floated to a slightly rough surface.

C. Surface shall not deviate more than 1/4-inch in 10 feet.

D. Unless otherwise indicated, horizontal surfaces of concrete pavement which will be exposed shall be given a light to medium broom finish, with direction of grooves in concrete surface perpendicular to length of concrete sidewalk and as indicated on the Contract Documents. After concrete has set sufficiently to prevent coarse aggregate from being torn from surface, but before it has completely set, brooms shall be drawn across it to produce a pattern of small parallel grooves. Broomed surface shall be uniform, with no smooth, unduly rough or porous spots, or other irregularities. Do not dislodge coarse aggregate by brooming operation.

E. Concrete shall not be permitted to dry out, and shall be kept continuously moist from time of placing until end of curing period, or until curing membrane is applied.

F. Immediately following finishing operations, arrises at edges and both sides of expansion joints shall be rounded to a 1/4-inch radius.

G. Finished concrete surface for base for unit pavement systems shall be wood floated to a slightly rough surface texture. Surface shall not deviate more than 0.25-inch in 10-feet and shall not deviate more than +/- 0.25-inches from finish grade less thickness of unit pavers plus specified depth of setting bed.

H. Correcting imperfections after concrete pavement operations cease:

1. If, upon review by the subcontractor responsible for installing unit pavers, areas of the concrete base slab are found to be too high in elevation and will not permit the correct depth of setting bed to be installed then concrete paving sub-contractor shall return to the project site and grind off the areas of concrete pavement that are determined to be too high.

2. If, upon review by the subcontractor responsible for installing unit pavers, areas of the concrete base slab are found to be too low in elevation and will require setting bed thickness in excess of 1.25X of the specified thickness then concrete paving subcontractor shall return to the project site and spread an approved latex-modified thin set mortar to the full extent of the offending area.
3. All corrective work shall be performed immediately upon notification and at no additional cost to the Cemetery, including costs associated with delays of installing unit pavers.

3.10 CURING

A. It is essential that concrete be kept continuously damp from time of placement until end of specified curing period.

B. All concrete pavement surfaces and slabs shall be moist cured by a covering of waterproofing paper, polyethylene film or curing compound.

C. Moist cure: Cover with waterproof paper or polyethylene film with edges lapped and sealed in such a manner to prevent moisture escaping from the concrete. Maintain in place for not less than 7 days.

D. If paper is used, pavement surface shall be damp when the covering is placed over it, and shall be kept damp by means of a fog spray of water, applied as often as necessary to prevent drying, but not sooner than 24 hours after placing concrete.

3.11 CONTROL JOINTS

A. Sawn Joints: Control joints indicated shall be sawn by using a diamond blade concrete power saw.

1. Saw joints shall be straight and true to the Contract Documents. Joint shall be made after concrete is finished and when the surface is stiff enough to support the weight of workmen without damage to the slab, but before slab has achieved its final set. Saw cut joints shall be straight and accurate to line.
2. Saw cut joints shall be sawn flush to vertical surfaces. Hand grinding may be required.
3. Saw shall cut into slab at least 1.5 inches, but in no case less than 33 percent of slab thickness.
4. Where indicated and at all running bond joint patterns, provide a plunge cut with concrete power saw to 50 percent depth of the slab.
5. Provide a 3/8th inch ground bevel to retrace the sawn joints.

3.12 COLD WEATHER CONCRETING

A. Materials for concrete shall be heated when concrete is mixed, placed, or cured when the mean daily temperature is below 40 degree Fahrenheit or is expected to fall to below 40 degree Fahrenheit within 72 hours, and the concrete after placing shall be protected by covering, heat, or both.

B. Details of handling and protecting of concrete during freezing weather shall be subject to the approval and direction of the Resident Engineer. Procedures shall be in accordance with provisions of ACI 306R.

3.13 HOT WEATHER CONCRETING

A. Concrete just placed shall be protected from the direct rays of the sun and the forms and reinforcement just prior to placing shall be sprinkled with cold water. Every effort shall be made to minimize delays that will result in excessive mixing of the concrete after arrival on the job.

B. During periods of excessively hot weather (95 degree Fahrenheit., or above), ingredients in the concrete shall be cooled insofar as possible and cold mixing water shall be used to maintain the temperature of the concrete at permissible levels all in accordance with the provisions of ACI 305. Any concrete with a temperature above 95 degree Fahrenheit. when ready for placement will not be acceptable, and will be rejected.

C. Temperature records shall be maintained throughout the period of hot weather giving air temperature, general weather conditions (calm, windy, clear, cloudy, and the like.) and relative humidity. Records shall include checks on temperature of concrete as delivered and after placing in forms. Data should be correlated with the progress of the work so that conditions surrounding the construction of any part of the structure can be ascertained.

3.14 SEALING OF JOINTS

A. Clean joint surfaces immediately before installation of sealant and other materials specified in this Section.

1. Remove all loose materials, dirt, dust, rust, oils and other foreign matter that will impair the performance of joint material.
2. Do not limit cleaning of joint surfaces to solvent wiping; use methods such as grinding, etching or other manufacturer's recommended means to clean the joint surfaces, assuring that the sealant materials will obtain positive and permanent adhesion.
3. Set joint fillers at proper depth and position as required for installation of bond breakers, backer rods, and sealants. Do not leave voids or gaps between the ends of joint filler units.
    a. Smooth Edged Joints: For joints between two concrete slabs or where new concrete abuts smooth-edged materials, use either cork joint filler or closed cell polyurethane joint filler.
    b. Irregular Edged Joints: For joints where new concrete abuts granite curbs or other irregular edges, use closed cell polyurethane joint filler.
    c. Prime all joint surfaces; Do not allow the primer/sealer to spill or migrate onto adjoining surfaces.

B. Install bond breaker tape in relaxed condition as it comes off the roll. Do not stretch the tape. Lap individual lengths.

C. Prevent three-sided adhesion by use of bond breaker tapes or backer rods at the back of the joint. Install backer rods for all liquid sealants, except where specifically recommended against by sealant manufacturers. Install backer rods immediately before sealants, do not permit backer rods to get wet. Install backer rods at the proper depth to create the specified sealant depth, avoid placing backer rods too deep that will result in sealant failure due to excessive sealant depth. Backup material shall be suitable size and shape so that when compressed 20 to 50%, it will fit in all joints where required. Do not cut or puncture the surface skin of the rod.

D. Apply, tool and finish sealant in accordance with manufacturer's recommendations.

E. Install sealants with ratchet handgun or other approved mechanical gun. Where gun application is impracticable, install sealant by knife or by pouring, as applicable. "Gun" devices shall have nozzles of proper size and shall provide sufficient pressure to completely fill joints as detailed.

3.15 PROTECTION OF CONCRETE SURFACES

A. Concrete surfaces shall be protected from traffic or damage until surfaces have hardened sufficiently. If necessary 1/2 inches thick plywood sheets shall be used to protect the exposed surface.

B. The Contractor shall provide adequate surveillance for all poured-in-place concrete pavements until concrete has set firmly, to prevent unwarranted markings of the concrete surface. Any unauthorized marking or graffiti in the finished surfaces shall be a cause for rejection by the Resident Engineer and replacement by the Contractor.

3.16 SURFACE SEALER

A. Following the 28-day curing period, apply the Alkoxysilane based surface sealer to the dry concrete surface.

B. All concrete surfaces shall be dry, clean and sound before application of surface sealant. Remove all grease, curing compounds, surface treatments, coatings, oils, etc. by sand or shot blast.

C. Apply in accordance with manufacturer’s written instructions. Apply in a uniform coat taking care not to let the product run. Apply subsequent passes ‘wet on wet’ until the required consumption is achieved. On horizontal surfaces application of surface sealer may be made by flooding technique with distribution by brush or squeegee. Avoid surface ponding.

3.17 ACCEPTANCE STANDARDS

A. The following acceptance standards shall be applied to this Contract. These standards are considered superior to typical industry standards. Any portion of the concrete paving that does not come up to these required acceptance standards shall be removed at the direction of the Resident Engineer. Saw cut pavement at nearest adjacent tooled joint, remove concrete pavement and discard off site in a legal manner and replace with new concrete pavement meeting the requirements of this Section.

1. All panels of concrete shall have consistent color rendition within the panel and all panels of the same color admixture shall be identical in color as determined by the Resident Engineer.
2. Pavement surfaces shall be free of all cracking.
3. Pavement surfaces shall not pond water.
4. Pavement surfaces shall be free of visible high and low spots.
5. Joints shall be straight, true, uniform in width and free from twists, bends, kinks and misalignments.
6. Broom finish shall not be too coarse in the opinion of the Resident Engineer.
7. Broom finish shall be constant and complete between joints without bare spots, lifts or disconnections in broom pattern.
8. Pavement shall show no graffiti. Pavement shall show no rubbed surfaces indicative of attempts to erase graffiti.
9. Expansion joints and control joints shall be placed as required by the Contract Documents.
10. Concrete surfaces shall be free of all stains, including those created during the course of the construction by the Contractor, caused by natural events, or caused by vandalism.
11. All joints and expansion joints shall be flush.
12. Pours shall have the specified expansion joints cast into them.
13. Pours shall conform to the Contract Documents as determined by the Resident Engineer.
14. All forms shall be removed from the site.
15. Detectable warning pavers are flush with the surrounding concrete pavement in locations indicated on the Drawings and in conformance with the requirements of these Specifications.

END OF SECTION

Section 32 14 40

STONE UNIT PAVING MUD SET

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Requirements set forth herein are in addition to and shall be considered as complementary to the Terms and Conditions for Construction and the balance of Divisions 00 and 01 and Technical Specifications.

B. All Contractors, Subcontractors, Vendors and the like shall be required to familiarize themselves with said provisions.

1.2 SUMMARY

A. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to furnish and install designated granite paving on latex modified setting bed and related items as indicated on the Contract Documents, as specified in this Section, and includes, but is not limited to, the following items:

1. Granite pavers on concrete base slab
    a. Orthogonal cut pavers
    b. Radial cut pavers

1.3 RELATED WORK UNDER OTHER SECTIONS

A. The following sections include work related to this Section:

1. Section 04 1010 Site Stone
2. Section 07 9200 Joint Sealants
3. Section 32 1313 Reinforced Concrete Paving for concrete base under unit pavers

1.4 REFERENCES:

A. Referenced Standards: Comply with applicable requirements of the following standards and those others referenced in this Section. Where these standards conflict with other specified requirements, the most restrictive requirements shall govern.

1. New York State Department of Transportation - Standard Specifications, Construction and Materials current edition.

2. ACI: American Concrete Institute
    a. 530/530.1Building Code Regulations for Masonry Structures and Specifications for Masonry Structures and Commentaries
3. ASTM: American Society for Testing and Materials
    a. C 33 Specification for Concrete Aggregates
    b. C 97Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone
    c. C 99 Standard Test Methods for Modulus of Rupture of Dimension Stone
    d. C 119 Standard Terminology Relating to Dimension Stone

e. C 136Test Method for Sieve Analysis of Fine and Coarse Aggregates
f. C 144Specification for Aggregate for Masonry Mortar
g. C 150 Specification for Portland Cement
h. C 170 Standard Test Method for Compressive Strength of Dimension Stone
i. C 241Standard Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic
j. C 270Standard Specification for Mortar for Unit Masonry
k. C 615 Standard Specification for Granite Dimension Stone
l. C 880 Standard Test Method for Flexural Strength of Dimension Stone
m. C1019Standard Test Method for Sampling and Testing Grout
n. C1353 Standard Test Method for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic
o. C1528 Standard Guide for Selection of Dimension Stone for Exterior Use

4. National Building Granite Quarries Association, Inc. (NBGQA): Specifications for Architectural Granite
5. Building Stone Institute: “Recommended Practices for the use of Natural Stones in Building Construction
6. Portland Cement Association “Cold Weather Construction Requirements” (PCA)
7. “Recommended Practices for Cold Weather Masonry Construction" by the International Masonry Industry All-Weather Council.
8. “Specification for Masonry Structures and Commentary (ACI 530.1-08/ASCE 6-081/TMS 602-08, Masonry Standards Joint Committee, comprise the American Concrete Institute, the Structural Engineering Institute of the American Society of Civil Engineers and The Masonry Society.
9. ACI: American Concrete Institute
   a. 530Building Code Regulations for Masonry Structures and Specifications for Masonry Structures and Commentaries

1.5 ACTION SUBMITTALS

A. Shop Drawings: Submit Shop Drawings for each piece of stone. Include plans and details as required to completely show materials, layout and jointing for all items required. Shop Drawings requiring accurate dimensional relationships to as-built construction, shall be prepared following a review and confirmation of as-built measurements and conditions for areas scheduled to receive site improvements. Shop drawings should show all aspects of construction, including but not limited to cut outs, drilled holes, points for attachment for site furnishings and site improvements specified elsewhere.

   1. Coordinate shop drawings with the requirements of applicable Sections of Division 03 Concrete as indicated and specified.
   2. Coordinate shop drawings with the requirements of applicable Sections of Division 04 Masonry as indicated and specified.
   3. Coordinate shop drawings with the requirements of applicable Sections of Division 07 Thermal and Moisture Protection as indicated and specified.
   4. Coordinate shop drawings with the requirements of applicable Sections of Division 32 Exterior Improvements as indicated and specified.

B. Written procedures for cold weather work:

   1. Submit procedure for cold weather work for review and approval by the Owner’s Representative.

C. Material Samples: Samples of the following shall be submitted:

1. Stone: samples shall fully demonstrate color, shade, veining, texture, range, and finish.

Item	Quantity and Size
Unit Pavers	Six (6) Pieces (12-inch x 12-inch x 1.25-inch)
Corinthian Granite – thermal finish	Six (6) Pieces (12-inch x 12-inch x 1.25-inch)

2. Full sized pieces shall be to size, shape and form as shown on the Detailed Drawings. Show finish of exposed-to-view and hidden faces, radius and arriss edges, eased edges at joints.

D. Test Reports: Submit reports from tests conforming to ASTM C 67 methods indicating:

1. Compressive strength, psi. (ASTM C 170).
2. Density, pounds per cubic foot (ASTM C 97).
3. Absorption by weight, percentage (ASTM C 97).
4. Abrasion resistance (ASTM C 241).
5. Flexural strength pounds per square inch, (MPa) (ASTM C 880).
6. Modulus of rupture, average (pounds per square inch) (ASTM C 99).

E. Product Data: For the following:

1. Mortar and grout materials. Provide color chart showing range of grout color for selection.
2. Edge restraints where required.

F. Samples:

1. Joint materials for color selection. Provide mortar grout color chart for mortar joint color selection. Provide same for elastomeric sealant selections.

G. Adhesion and Compatibility Test Reports: From latex-additive manufacturer for mortar and grout containing latex additives.

1.6 PRE-INSTALLATION CONFERENCE

A. Pre-installation Conference:

1. Schedule a meeting with the stone paving installer, General Contractor, Owner's Representative and the Owner at a time sufficiently in advance of paving installation to permit coordination.
2. At the meeting review paving system quality control requirements including details of construction, outstanding submittals, Drawings and Specifications, and on site conditions affecting or which may affect installations.
3. Contractor shall record discussions, including agreements or disagreements on matters of quality control. General Contractor shall furnish copies of recorded discussions to each participant within 3 working days of the meeting.

1.7 QUALITY ASSURANCE

A. Installer Qualifications An experienced installer who has completed granite unit paver installations similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance. The installer's work includes, but is not necessarily limited to, the following:

1. All preparation for granite unit paver work, including but not limited to submittals, mock-ups, and sample installations as specified herein.
2. All anchors, supports, embeds and fasteners for the above, installation of same.
3. All sealants and joint fillers in conjunction with the above.

B. Source Limitations: Obtain each type joint material, and setting material from one source with resources to provide materials and products of consistent quality in appearance and physical properties, including the capacity to furnish material without delaying the progress of the Work.

C. Mockups: Before installing granite pavers, build mockups for each form and pattern of unit pavers required to verify selections made under sample Submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for the completed Work, including same base construction, mortar joints, special features for expansion joints, and contiguous work as indicated:

1. Coordinate the construction of mockups under the work of this Section 321440 with the materials mockups specified under other Specification Sections.
2. Build mockups in the location and of the size indicated or, if not indicated, as directed by Owner's Representative.
3. Notify Owner's Representative seven days in advance of dates and times when mockups will be constructed.
4. Demonstrate the proposed range of aesthetic effects and workmanship.
5. Obtain Owner's Representative's approval of mockups before starting unit paver installation.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

D. Constructed Samples

1. Notify the Owner's Representative when each of the different types of granite paving are going to be installed. These types of granite paving include:
   a. Orthogonal Granite pavers on concrete base slab
   b. Radial Granite pavers on concrete base slab

2. Install approximately 100 square feet of granite to allow Owner's Representative to inspect for approval of installation and finish quality.

1.8 COLD AND HOT WEATHER PRECAUTIONS

A. Follow recommended practices for cold and hot weather masonry construction, in accordance with the standards outlined in the following:

1. PCA “Cold Weather Construction Requirements” (PCA)
2. “Recommended Practices for Cold Weather Masonry Construction" by the International Masonry Industry All-Weather Council.
3. “Specification for Masonry Structures and Commentary (ACI 530.1-08/ASCE 6-081/TMS 602-08)
4. As directed by the Owner’s Representative.

B. Submit procedure for cold weather work for review and approval by the Owner’s Representative.

PART 2 - PRODUCTS

2.1 GRANITE

A. Granite shall be sound and uniform in quality, texture, and strength, and shall be free of flaws, reeds, rifts, laminations, cracks, seams, starts, or other defects that may impair its strength, durability, function, or appearance. Exposed surfaces shall be free from spots, spalls, chips, stains, discoloration, or other defects that would affect its appearance.

B. Granite shall conform to the requirements of ASTM C615 Standard Specification for Granite Dimension Stone. Physical properties shall confirm to C615, Table 1, as follows:

Physical Property	Test Requirements	Test Method(s)
Absorption by weight, max, %	0.4	C97/C97M
Density, min, lb/ft3 [kg/m3]	160 [2560]	C97/C97M
Compressive strength, min, psi [MPa]	19 000 [131]	C170/C170M
Modulus of rupture, min, psi [MPa]	1500 [10.3]	C99/C99M
Abrasion resistance, min, $H_a^{A,B,C}$	25	C241/C241M/C1353
Flexural strength, min, psi [MPa]	1200 [8.3]	C880/C880M

[A] Pertains only to stone subject to foot traffic.

[B] The supplier of the No. 60Alundum abrasive, Norton, has indicated that the formula for Norton treatment 138S has been changed. The new abrasive is currently more aggressive, resulting in lower abrasive hardness values (Ha) than when the standard was initially established. As such, care should be taken when interpreting Ha values from tests using the new abrasive, particularly with regard to current ASTM stone standard specification requirements for abrasion resistance, which were developed when the original abrasive was still in use. Committee C18 is actively studying alternatives to address this issue.

[C] Abrasion Resistance Test Method C1353 will eventually replace Test Method C241/C241M and it is not necessary to perform both tests. Availability of the proper equipment and materials by the testing laboratory may determine which test is performed.

2.2 GRANITE UNIT PAVERS

A. In accordance with the requirements of Section 041010 Site Stone for materials, fabrication, delivery and on-site storage and stockpiling.

2.3 STONE FINISHES

A. Finish: The product of multiple manufacturers, the stone selected will be subjected to an extensive submittal and inspection process to determine the most suitable finish for each stone in conjunction with each other. In so far as different manufacturers have different finish names, standards and production techniques to produce surface finish and texture, the submittal process may require multiple rounds and requests for alternative finishes. It is the intent of the design process that the stones specified under this Article shall be sawn all sides. Faces and surfaces hidden from view shall remain sawn. Faces and surfaces exposed to view shall be finished one of the following finishes or combination thereof on adjacent faces, depending on the side-by-side comparison of the stones during review. Selection of finish shall add no additional cost to the Owner.

B. Definition of Stone Finishes:

1. Thermal (Flamed): The finish produced by application of high-temperature flame to the surface of the stone. Texture shall be non-slip with depth of pitted texture no greater than 2 mm. Large surfaces may have shadow lines caused by overlapping of the torch. This finish will vary in texture and depth between different types of stone as the finish is largely dependent upon the grain structure of the stone. Not recommended for sedimentary stones.

C. Finish shall be per the Contract Documents and approved Shop Drawings

1. Non-exposed-to-view surfaces shall be sawn.
2. Horizontal walking surfaces shall be thermal finished based on finishes selected by the Owner's Representative during the sample review process.

2.4 FABRICATION REQUIREMENTS

A. Fabrication:

1. Size and Dimension: Stone shall be of the sizes and dimensions indicated on the Contract Documents and approved Shop Drawings.
2. Bottoms and sides of stone pieces that will be concealed in the finished work shall be sawn to true planes. Sawn pieces of stone shall be cleaned of rust stains and iron particles.
3. Unit pavers:
   a. Shall have 1/16th inch plus or minus dimensional tolerance for horizontal measurements noted on the Drawings.
   b. Unit pavers shall be gauged and calibrated to consistent thickness plus or minus 1/6th- inch dimensional tolerance.
   c. Out of Square: plus or minus 1/16th-inch difference of diagonals for square pavers.

B. Tolerances

1. Joint Width: Cut stone to produce uniform joints of 1/4 inch plus or minus 1/16th inch
2. Flatness Tolerance: Variation from true plane, or flat surfaces, shall be determined by use of a 4-foot long straightedge, applied in any direction on the surface. Such variations shall not exceed 1/8 of the specified joint width as variation from true plane.
3. Stone Fabrication Tolerances:

a. Stone thicknesses greater than 2-inches: Plus or minus 1/16th-inch of the nominal thickness.
b. Overall face size of veneer stones: Plus or minus 1/16th-inch for height, width and depth dimensions.
c. Out of square: Plus or minus 1/16th-inch difference of diagonals.

C. Inspect finished stone units at fabrication plant. Replace defective units.

2.5 POINTING GROUT MATERIALS FOR GRANITE PAVERS

A. Laticrete 1500 Sanded Grout, color selected by the Owner's Representative.

B. Water when required shall be potable with salt index less than 1 mmhos/cm (dS/m)

2.6 MODIFIED MORTAR SETTING-BED MATERIALS FOR GRANITE PAVERS

A. The setting bed mortar system to support the granite paving shall be manufactured by Laticrete International, Bethany CT and shall include the following products:

1. Mortar shall be Laticrete 3701 Fortified Mortar, a premixed, bagged polymer fortified blend of polymers, portland cement and graded aggregates, or approved equal
2. Slurry bond coat shall be Laticrete 254 Platinum, a premixed, bagged polymer fortified, thin set mortar or approved equal.
3. Setting bed mortar system shall be single manufacturer.

B. Water: Potable with salt index less than 1mmhos/cm (dS/m).

PART 3 - EXECUTION

3.1 TRANSPORT, DELIVERY, STORAGE AND HANDLING

A. The Contractor shall provide sufficient fabricated pieces of stone to the required sizes to complete the work of the Contract. Locate, procure and delivery stone pieces sufficiently in advance of when they will be installed to meet Project schedules.

B. Stone shall be carefully packed and banded by the supplier for shipment. Prior to shipping, stone shall be stored on wood skids or pallets, covered with non-staining, waterproof membrane bundles and protected from the weather. Skids shall be placed and stacked in such a manner as to evenly distribute the weight of the stone and to prevent breakage, cracking, and damage to stone during loading, transport, offloading and stockpiling.

C. Stone pieces shall be unwrapped and inspected by the contractor upon delivery to the site. Broken or damaged pieces shall become the property of the contractor who shall replace the damaged stones at no additional cost to the Owner. The contractor may forgo inspection upon delivery and assume all responsibility for replacement and maintaining project schedules.

D. Stone shall be stored in an area of the construction site that is least susceptible to damage from ongoing construction activity. Stone shall be kept in factory wrapped, waterproof

bundles on wood skids until the job site is ready to receive for installation. Stone shall not be permitted to be in direct contact with the ground any time during storage.

E. Once unwrapped stone shall be placed and stacked on wood timbers or platforms at least 2-inches above ground and stacked in such a manner as to evenly distribute the weight of the stone and to prevent breakage, cracking, and damage to individual stones. Stone material shall be stored in such a manner as to allow air to circulate around the stone material. Stone shall not be permitted to be in direct contact with the ground any time during storage.

F. If storage is to be prolonged, wrap stone in polyethylene sheeting to keep stone dry. Any holes or slots in the stone that are capable of collecting water shall be temporarily covered or plugged to prevent freezing of collected water. Such covers or plugs shall be removed immediately prior to installation of the piece.

G. Stone shall be carefully handled to prevent chipping, breakage, soiling, or other damage. Pinch or wrecking bars shall not be used without protecting edges of stone with wood or other rigid materials. Stone units shall be lifted with wide-belt type slings wherever possible; wire rope or ropes containing tar or other substances that might cause staining or damage to stone finish shall not be used.

H. Stone damaged in any manner up until the time of formal written Final Acceptance by the Owner will be rejected and shall be replaced with new materials at no additional cost to the Owner.

3.2 NOTIFICATION

A. Notify the Owner's Representative when stone pieces are scheduled for delivery and schedule his/her attendance on site to witness delivery and stockpiling. The Owner's Representative will inspect the stone pieces for conformance to the requirements of the Contract.

3.3 EXAMINATION

A. Examine surfaces indicated to receive unit paving, with installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Place unit pavers only after concrete base slab has fully cured and reached its full compressive strength. Schedule construction to anticipate cure time of concrete base. Cue time shall be no less than 30 days.

C. Proceed with installation of unit pavers only after unsatisfactory conditions have been corrected.

3.4 PREPARATION

A. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.

B. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.

3.5 INSTALLATION OF GRANITE UNIT PAVERS - GENERAL

A. Do not use granite pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

B. Cut granite units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. All cutting and patching required to complete the work shall be done (including the filling and closing of all openings) with water-cooled radial cut-off type masonry saws with diamond-tipped blade for a sharp, straight edge. Cut edges shall be plumb and straight. Scoring and breaking will not be acceptable. Hammer cutting is not acceptable.

1. Where unit pavers must be shaped to meet vertical edges, flush edges or any site furnishing or site element that requires special cutting of the stone paver, sawcut the granite to match the shape of the adjacencies to produce a consistent 1/4-inch joint width.

C. Joint Patterns and Locations: As indicated on the Drawings.

D. Tolerances: Do not exceed 1/32nd-inch unit-to-unit offset from flush (lippage) nor 1/8th-inch in 24 inches or 1/4-inch in 10-feet from level, or indicated slope, for finished surface of paving.

E. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated. Provide joint filler as backing for sealant-filled joints where indicated. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 079200 Joint Sealants.

3.6 SETTING GRANITE PAVERS - GENERAL

A. Granite pavers shall be set on a latex modified setting bed over the prepared concrete base. Setting bed shall be protected from damage prior to setting pavers.

B. Only competent workmen under adequate supervision shall perform the work of setting granite pavers. Granite pavers shall be set true to the required lines and grades in the pattern detailed on the Contract Documents.

C. After the setting bed is applied, pavers shall be carefully placed by hand, set true to the required lines and grades in the pattern shown on the Contract Documents. Accurate alignment shall be maintained. The Owner's Representative will approve the start of paving layouts.

D. Pavers shall be neatly cut and fitted at all perimeters and closures to fit neatly and closely to the standards noted in this Section. Pavers shall be carefully placed and cut as required to achieve the joint widths specified in this Section. Surface edge of one paver shall be level with the next adjacent pavers so that no voids, rocking motions, or tripping hazards are encountered. Maintain installation tolerance defined in this Section. All finish paved areas shall slope to drain at a minimum of 1-percent. Notify the Owner's Representative immediately if pavements do not drain at a minimum of 1-percent.

E. After a sufficient area of pavers has been installed, joints of pavers shall be filled with latex modified grout, as specified, performed and paid for under this Section.

F. Newly laid pavers shall be protected at all times by panels of plywood. These panels may be advanced as work progresses; however, the plywood protection shall be kept in areas which will be subjected to continued movement of materials and equipment. All necessary precautions shall be taken in order to avoid depressions and protect paver alignment.

3.7 GRANITE PAVERS: MODIFIED MORTAR MIX – GENERAL PROPORTIONING AND MIXING

A. General: Comply with referenced standards and with manufacturers' written instructions for mix proportions, mixing equipment, mixer speeds, mixing containers, mixing times, and other procedures needed to produce setting-bed and joint materials of uniform quality and with optimum performance characteristics. Discard mortars when they have reached their initial set.

B. Cement-Paste Bond Coat: Mix bond coat to a consistency similar to that of thick cream and consisting of either neat cement and water or cement, sand, and water.

1. For latex-modified Portland cement setting-bed mortar, substitute latex admixture for part or all of water per directions of latex-additive manufacturer.

C. Latex-Modified Portland Cement Setting-Bed Mortar: Proportion and mix Portland cement, aggregate, and latex additive for setting bed to comply with directions of latex-additive manufacturer and as necessary to produce stiff mixture with a moist surface when bed is ready to receive pavers.

D. Latex-Modified Portland Cement Slurry Bond Coat: Proportion and mix Portland cement, aggregate, and latex additive for slurry bond coat to comply with directions of latex-additive manufacturer.

E. Latex-Modified Portland Cement Grout: Add latex additive to dry grout mix in proportion and concentration recommended by latex-additive manufacturer. Proportion cement and aggregate to comply with directions of latex-additive manufacturer.

1. Job-Mixed, Pigmented Grout: Select and proportion pigments with other ingredients to produce color required. Do not exceed pigment-to-cement ratio of 1 to 10, by weight.
2. Job-Mixed, Colored-Aggregate Grout: Produce color required by combining colored aggregates with Portland cement of selected color.

3.8 GRANITE PAVING: BOND BREAKER FOR CONTROL JOINTS

A. Accommodating thermal movement during the temperature swings winter to summer of stone paving shall be achieved by use of bond breaker of asphalt impregnated construction paper for joints between paving bands.

B. Utilize diamond cutting blades to prevent damage and spalling of the stone pavers. Depth of saw cutting shall extend through the stone paver but shall not damage the underlying setting bed mortar.

C. Extend expansion joints upward from concrete base slab through stone paving in all conditions including at vertical surfaces such as building facades and bollards.

D. Provide vertical bond breaker of asphalt impregnated construction paper at the longitudinal joints between stone paving bands and between transverse joints. Provide required pointed joint of latex modified mortar against vertical bond breaker as shown on the Detailed Drawings.

3.9 MORTAR SETTING-BED APPLICATIONS FOR GRANITE PAVERS

A. Saturate concrete subbase with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.

B. Apply mortar-bed bond coat over surface of concrete subbase about 15 minutes before placing mortar bed. Do not exceed 1/16th inch thickness for bond coat. Limit area of bond coat to avoid its drying out before placing setting bed.

C. Apply mortar bed over bond coat; spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.

D. Mix and place only that amount of modified mortar bed that can be covered with pavers before initial set. Before placing pavers, cut back, bevel edge, and remove and discard setting-bed material that has reached initial set.

E. Wet stone pavers before laying if the initial rate of absorption exceeds 30 g/194 sq. cm per minute when tested according to ASTM C 67. Allow units to absorb water so they are damp but not wet at time of laying.

F. Place pavers before initial set of cement occurs. Immediately before placing pavers on modified mortar bed, apply uniform 1/16th inch-thick bond coat to mortar bed or to back of each paver with a flat trowel.

G. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single operation before initial set of mortar; do not return to areas already set or disturb pavers for purposes of realigning finished surfaces or adjusting joints.

3.10 JOINTS

A. Spaced Joint Widths: Provide 1/4-inch nominal joint width with variations not exceeding plus or minus 1/16th-inch.

B. Grout joints as soon as possible after initial set of setting bed. Force grout into joints, taking care not to smear grout on adjoining pavers and other surfaces. After initial set of grout, finish joints by tooling to produce a slightly concave polished joint, free from drying cracks.

C. Cure grout by maintaining in a damp condition for seven days, unless otherwise recommended by latex-additive manufacturer.

3.11 REPAIRING, POINTING, AND CLEANING

A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units

and install in same manner as original units, with same joint treatment and with no evidence of replacement.

B. Pointing: During tooling of joints, enlarge voids or holes and completely fill with grout. Point joints at sealant joints to provide a neat, uniform appearance, properly prepared for sealant application.

C. Cleaning: Remove excess grout from exposed paver surfaces; wash and scrub clean.

END OF SECTION 321440

Section 32 16 40

STONE CURB

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Requirements set forth herein are in addition to and shall be considered as complementary to the Terms and Conditions for Construction and the balance of Divisions 00 and 01 and Technical Specifications.

B. All Contractors, Subcontractors, Vendors and the like shall be required to familiarize themselves with said provisions.

1.2 DESCRIPTION OF WORK

A. The work of this Section consists of providing labor, equipment, materials, incidental work, and construction methods necessary to furnish and install new granite curb, remove, stockpile and reset existing granite curb, as indicated and as specified, including, but not limited to:

1. Planter Curb
    a. Vertical granite planter curb
    b. Solid granite curb transition piece.
    c. Resetting of existing granite curb.

1.3 RELATED WORK UNDER OTHER SECTIONS

A. The following items of related work are specified and included in other Sections of the Specifications:

1. Section 024113 Selective Site Demolition
2. Section 033301 Cast-in-Place Concrete – Site
3. Section 041010 Site Stone
4. Section 310000 Earthwork
5. Section 312500 Erosion and Sedimentation Control

1.4 SUBMITTALS

A. Submit samples of stone curb to Owner’s Representative for approval. Samples shall be representative of curb units. Sample size shall be 12 inches long, minimum. Submit name of stone quarry supplying stone curbing for approval by the Owner’s Representative.

B. Submit complete shop drawings of stone curbing for Owner’s Representative's approval

C. Shop drawings shall indicate size, dimension, and finish of each curb type

1. Submit a complete plan and schedule for quantity, lengths, and size for all curbing on the project.

1.5 CONTRACT PERFORMANCE REQUIREMENTS

A. The following standards shall apply to the work of this Section.

1. American Society for Testing and Materials (ASTM):
   a. C 131 Resistance to Degradation of Small-Size, Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
   b. C 615 Granite Dimension Stone
2. New York State Department of Transportation - Standard Specifications, Construction and Materials current edition.

1.6 QUALITY ASSURANCE

A. Granite curb materials and construction shall conform to the applicable portions of the following:

1. Section 041010 standards for Cubic Granite

B. Stone for all curbing shall be supplied from a single source for entire project.

C. Source of stone shall be approved by Owner's Representative prior to construction

1.7 DELIVERY, STORAGE, AND HANDLING

A. Curb units shall be delivered to the job adequately protected from damage during transit.

1. Curb shall be protected against staining, chipping, and other damage. Cracked, badly chipped, or stained units will be rejected and shall not be employed in the work.
2. Store pallets of curbing on pavement or other hard, durable surfaces that will not compact as a result of the weight of the pallets of curbing. Prevent steel strapping from pallets from rusting and staining of pavement. Remove and replace all pavement stained by rusting steel strapping of pallets.

1.8 REUSE OF EXISTING GRANITE CURBING

A. Maximum reuse shall be made in the new work of existing granite curbing removed, stacked and the work of removal and stacking paid for under Section 024113, Selective Site Demolition, of this Specification.

B. Existing curb to be reused shall be reset in accordance with the requirements of this Section.

C. Review if existing granite curbing will be reused adjacent to unit pavers.

D. Existing granite curbing to be reused shall be dressed on the back face (unit paver face) to a depth of 4 inches to create a flat surface against which unit pavers can be placed without deformation of pavement line from straight and true alignment.

PART 2 - PRODUCTS

2.1 GRANITE CURB

A. Granite Planter Curb: Granite shall be structural granite conforming to ASTM C 615, Class I Engineering Grade, suitable for curbstone use. Curb shall be light gray, free from seams which impair structural integrity, and with percentage of wear less than 32 percent, as determined by ASTM C 131.

1. Top surface shall be sawn to an approximately true plane, having no projections or depressions greater than 0.125 inches and shall be peen hammered or thermal finished to create a non-slip surface.
2. Front and back arris lines shall be cut straight and true. Granite curb shall be dressed vertically on the back face to a depth of 4 inches from the back arris line such that there are no projections greater than one-sixteenth inch from the vertical. From that point downward there shall be no projection on the back surface that would exceed a batter of 4 inches in 12 inches.
3. The ends of the stone shall be squared with the planes of the top and face so that when the stones are placed end to end as closely as possible, no space shall show in the joint at the top and face of more than 1/4 inches, for the full width of the top and for 8 inches down on the face, after which the end may break back not over 8 inches, from the plane of the joint. The arris formed by the intersection of the plane of the joint with the planes of the top and exposed faces shall have no variation from the plane of the top and exposed faces greater than 1/8 inches.
4. Provide transition pieces in dimensions indicated on the Contract Documents.
5. Where transition piece is flush with surface of pedestrian pavement, exposed surface of granite shall have a thermal finish.

B. GRANITE FOR CURB

1. Granite shall be sound and uniform in quality, texture, and strength, and shall be free of flaws, reeds, rifts, laminations, cracks, seams, starts, or other defects that may impair its strength, durability, function, or appearance. Exposed surfaces shall be free from spots, spalls, chips, stains, discoloration, or other defects that would affect its appearance.
2. Granite shall conform to the requirements of ASTM C615 Standard Specification for Granite Dimension Stone. Physical properties shall confirm to C615, Table 1, as follows:

Physical Property	Test Requirements	Test Method(s)
Absorption by weight, max, %	0.4	C97/C97M
Density, min, lb/ft3 [kg/m3]	160 [2560]	C97/C97M
Compressive strength, min, psi [MPa]	19 000 [131]	C170/C170M

Modulus of rupture, min, psi [MPa]	1500 [10.3]	C99/C99M
Abrasion resistance, min, H_a[A,B,C]	25	C241/C241M/C1353
Flexural strength, min, psi [MPa]	1200 [8.3]	C880/C880M

[A] Pertains only to stone subject to foot traffic.

[B] The supplier of the No. 60Alundum abrasive, Norton, has indicated that the formula for Norton treatment 138S has been changed. The new abrasive is currently more aggressive, resulting in lower abrasive hardness values (Ha) than when the standard was initially established. As such, care should be taken when interpreting Ha values from tests using the new abrasive, particularly with regard to current ASTM stone standard specification requirements for abrasion resistance, which were developed when the original abrasive was still in use. Committee C18 is actively studying alternatives to address this issue.

[C] Abrasion Resistance Test Method C1353 will eventually replace Test Method C241/C241M and it is not necessary to perform both tests. Availability of the proper equipment and materials by the testing laboratory may determine which test is performed.

C. Granite types. In accordance with the Construction Documents for granite types for each piece of granite and required finishes.

1. Woodbury Gray™ Granite

D. Granite Supplier:

1. Polycor Granite 139 St. Pierre Street, Quebec City (Quebec) Canada G1K 8B9
   a. Northeast Rep: Igor Zgodic, C:202-870-2120, Igor.Zgodic@polycor.com

2.2 CEMENT MORTAR

A. Mortar for pointing joints between curbstones shall be a cement mortar composed of one part Portland cement and two parts sand, by volume with sufficient water to form a workable, stiff mixture.

2.3 CONCRETE

A. Concrete for Backing Up Curb: Concrete where designated for backing up curb shall be 4,000 psi, 3/4-inch, high early strength concrete.

PART 3 - EXECUTION

3.1 SETTING CURB

A. Experienced stonemasons shall set each piece of granite.

B. Curb shall be set in a 24-inch wide trench, with trench bottom at 18-inches below bottom of curb. Excavation shall be filled with s-inch depth of compacted dense graded crushed

stone provided, installed and paid for under the work of applicable Division 31 Sections related to earth moving.

C. Utilize templates or similar devices to ensure accurate alignment conforming to the requirements of the Contract Documents and approved Shop Drawing curb schedule.

D. Install all granite pieces in accordance with the requirements of the Contract Documents. Set all pieces accurately in locations indicated with arisses and faces aligned according to the relationships shown on the Contract Documents and approved Shop Drawings, as directed by the Owner's Representative and to indicated tolerances.

E. Following inspection of the trench and dense graded crushed stone by the Owner's Representative, provide wet concrete to completely support the curb throughout its length. Pour concrete and level off prior to placing granite on a latex modified mortar setting bed or support curb pieces with brick shims and pour concrete beneath the curb.

F. All spaces under the curb shall be filled with wet concrete so that the curb will be completely supported throughout its length.

G. After proper alignment of curbing has been established, place additional concrete surround to extend concrete up each face of curbing as detailed on the Contract Documents.

H. Vertical face of vertical curb shall be plumb, with curb top parallel to adjacent surface.

I. Curb shall be set accurately to line and grade. Curb alignment shall be uniform, with smooth and continuous arris lines. Radius curbs shall meet with a common tangent. Curb units shall be fitted together as closely as possible. Curb shall not be field cut.

J. Point mortar joints by placing and compacting mortar in layers not greater than 3/8 inch. Compact each layer thoroughly and allow mortar to become thumbprint hard before applying next layer. After pointing excess mortar shall be cleaned from curb surface.

K. Variation from Level: Do not exceed 1/8 inch in 10 feet.

L. Variation in Vertical Joint Width: 1/8-inch maximum variation top to bottom, front to back.

M. Variation in Plane between Adjacent Surfaces (Lipping): Do not exceed 1/16-inch difference between planes of adjacent units or adjacent surfaces indicated to be flush with units.

N. Backfill material on each side of curb shall be as specified for adjacent surface and shall be thoroughly compacted by means of power tampers. Extreme care shall be taken not to alter alignment. Curb sections disturbed during backfilling or otherwise shall be reset to line and grade, and properly backfilled.

END OF SECTION

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Section 32 30 00

SITE FURNISHINGS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Requirements set forth herein are in addition to and shall be considered as complementary to the Terms and Conditions for Construction and the balance of Divisions 00 and 01 and Technical Specifications.

B. All Contractors, Subcontractors, Venders, Landscape Architects and the like shall be required to familiarize themselves with said provisions.

1.2 DESCRIPTION OF WORK

A. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to furnish and install designated Site furnishings and related items as indicated on the Contract Documents, as specified in this Section, and includes, but is not limited to, the following items:

1. Rail Bike Loop Racks
2. Bench Installation (Product provided by University)
3. Copper Alloy Handrail

B. As indicated above, the Contractor shall install Owner-supplied Site Furnishings as part of the work of this Section.

C. The following sections include work related to this Section:

1. Section 024113 Selective Site Demolition
2. Section 033001 Cast-in-Place Concrete - Site
3. Section 041010 Site Stone
4. Section 004250 Stone Unit Masonry
5. Section 055200 Miscellaneous Site Metals Fabrication
6. Section 079000 Sealant Joints
7. Section 265010 Architectural Lighting and related Division 26 Sections
8. Section 310000 Earthwork

1.3 REFERENCES

A. The following standards shall apply to the work of this Section:

1. AWQS: Architectural Woodwork Quality Standards, 1973-2005 by the American Woodwork Institute
2. FSC: Forest Stewardship Council: http://ic.fsc.org/about-us.1.htm
3. APA: American Plywood Association
   a. AWPA, American Wood Protection Association: Book of Standards
   b. AWPA M2 (2011) Standard for Inspection of Treated Wood Products.

c. AWPA M4 (2011) Standard for the Care of Preservative-Treated Wood Products.
d. AWPA P5 (2010) Standard for Waterborne Preservatives.

4. ASME International (ASME)
   a. ASME B18.2.1 (2010) Square and Hex Bolts and Screws (Inch Series)
   b. ASME B18.2.2 (2010) Standard for Square and Hex Nuts
   c. ASME B18.6.1 (1981; R 2008) Wood Screws (Inch Series)
5. ASTM International, standards as applicable
   a. ASTM A 123 Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
   b. ASTM A 153 Standard Specification for Zinc Coatings (Hot-Dip) on Iron and Steel Hardware
   c. ASTM A 307 Standard Specification for Carbon Steel Bolts, Studs, and Treated Rod 60,000 PSI Tensile Strength
   d. ASTM D635 Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
   e. ASTM E84 Surface Burning Characteristics of Building Materials
6. ALSC: American Lumber Standard Committee: Grade Rules Writing Organizations
   a. ALSC PS 20 (2010) American Softwood Lumber Standard
7. New York State Department of Transportation - Standard Specifications, Construction and Materials current edition.
8. NSF/ANSI STANDARD 61

1.4 CERTIFIED WOOD:

A. Wood for benches shall be certified: manufacturer’s certification that wood was obtained from forests certified by FSC accredited certification body to comply with forest Stewardship Councils “Principles and Criteria.” Include cost of material and chain-of-custody certification number obtained from manufacturer.

1.5 SUBMITTALS - GENERAL

A. Construction Sequencing: provide recommended construction installation sequence for wood and steel benches in all locations.

B. Manufacturer's product literature and installation instructions: Submit manufacturer's material descriptions and installation instructions for the items described in this Section.

C. Color samples for plastics and paint coatings where applicable: Submit color chip or chips of color(s) for approval by Landscape Architect. Color chips shall be minimum 3 inches square prepared and coated as per specifications for review by the Landscape Architect prior to beginning the work of this Section.

D. Shop Drawings:

1. Submit complete shop drawings for all manufactured site furnishings.

1.6 EXAMINATION OF CONDITIONS

A. All areas affected by installation of site furnishings shall be inspected by the Contractor before starting work and any defects such as incorrect grading or inadequate drainage shall be reported to the LANDSCAPE ARCHITECT prior to beginning this work

B. The Contractor shall be solely responsible for judging the full extent of work requirements involved, including but not limited to the potential need for storing and maintaining components temporarily and/or handling components prior to final installation. Be familiar with existing conditions of the site before submitting a bid. Be fully responsible for carrying out all work required for fully and properly executing the work of the Contract, regardless of the conditions encountered in the actual work. No claim for extra compensation or extension of time shall be allowed on account of actual conditions inconsistent with those assumed, except those conditions described in the GENERAL REQUIREMENTS.

1.7 DAMAGE TO OTHER WORK

A. The Contractor shall be responsible for, and shall pay for repairs of any damage caused by this work, or the workers.

B. Repair of such damage shall be done by the Contractor who installed the work, and as directed by the LANDSCAPE ARCHITECT.

1.8 QUALIFICATIONS OF MANUFACTURERS

A. Contractor shall submit verification to the LANDSCAPE ARCHITECT stating the proposed manufacturers of the various site furnishing items is as specified. Alternative manufacturers, if proposed, shall have produced equivalent items of the required quality as specified for a minimum of 5 years.

1.9 QUALITY STANDARDS

A. Workmanship and finish shall be equal to the best practice of modern shops for each item of work. Fabrication shall be accomplished using the highest standards of workmanship. All work shall be executed by experienced mechanics and craftsmen, shall conform to the requirements of the Contract Documents.

B. Where work fabricated under other Sections has been delivered to the site and has dimensions or fabricated construction that does not fit the field conditions, notify the LANDSCAPE ARCHITECT of the discrepancy immediately. Follow up voice communication with a written correspondence detailing the discrepancy between delivered work and constructed condition.

C. General Material Standards:

1. Individual pieces shall be saw cut and carefully fitted together.
2. Sections shall be well formed to shape and size with sharp lines and angles.
3. Exposed surfaces shall have a smooth finish and sharp, well-defined lines and arrises.
4. Smooth and shape all edges completely free from nicks and machine marks.
5. All surfaces and connections of parts within site improvement items shall be without visible grinding marks, surface differentiation or variation, having specified finish.

6. All manufactured items shall have a high standard of surface smoothness as judged by the LANDSCAPE ARCHITECT.
7. Where welding is utilized in the manufacturing process, welds shall be continuous and shall extend for the entire length of the joints except where specifically indicated on the Contract Documents. All exposed welds shall be ground smooth.
8. Where stainless steel is exposed to view it shall have a finish equal to bead blast finish as defined in Section 055200 as approved by the LANDSCAPE ARCHITECT.
9. Weld with uncoated wire to prevent flux deposits. If coated wire is used, all flux residues shall be thoroughly removed and bare white metal exposed, prior to galvanization, if applicable. Where overlapping surfaces are welded, seal off contact area by welding all edges around contact area.
10. Full seam weld all shop connections and grind the welds flush and smooth.
11. For bolted and screwed field connections, draw up all threaded connections tightly.

1.10 DELIVERY, STORAGE AND HANDLING - GENERAL

A. Pack, handle, and ship bicycle racks, benches, handrails and miscellaneous items in suitable packs or pallets.

1. Lift with wide-belt slings; do not use wire rope or ropes that might cause staining. Move site furnishing items, as required to avoid torsion or wracking, or structural and finish damage, using dollies with wood supports. Protect against careless handling and vandalism
2. Store site furnishing items on wood skids or pallets with non-staining, waterproof covers. Arrange to distribute weight evenly and to prevent damage to units. Ventilate under covers to prevent condensation.

B. The LANDSCAPE ARCHITECT will reject items that are rusted or damaged because of non-compliance with these conditions. Replace rejected items at no additional cost to the Owner.

1.11 GENERAL INSTALLATION

A. Provide and delivery all metal inserts, anchor slots, anchors, anchor bolts, fastenings, and fastening devices required for attachment of site furnishings and site furnishings specified under other Sections of this Specification under the work of this Section 323000.

B. Free-standing site improvement items shall be set plumb and horizontal regardless of the pitch of the finished surrounding grade unless otherwise shown on the Contract Documents. Locate as directed by the LANDSCAPE ARCHITECT.

C. Time the delivery of site furnishings to minimize the on-site storage time prior to installation. All stored materials shall be protected from weather, careless handling and vandalism.

D. Correctly locate all site furnishings. Take particular care to maintain shapes, plumb and level during the pouring of concrete.

E. All Work shall be accurately set to established lines and elevations and rigidly set in place.

1.12 COORDINATION

A. Coordinate the work of this Section with the work of other Sections. Verify dimensions and work of other trades that adjoin materials of this Section 323000 before installing items specified.

B. Obtain all necessary templates and patterns required from other trades for proper execution of work of this Section. Coordinate the delivery of items, templates, and patterns manufactured by other trades to maintain construction schedule. Receive from other trades items to be installed under this Section.

1.13 GUARANTEE

A. Furnish standard written manufacturer's guarantee in Owner's name covering all materials and workmanship under this Section, in addition to, and not in lieu of, guarantee requirements set forth under Division 1 Specification Sections, and other liabilities which the Contractor may have by law or other provisions of the Contract Documents.

B. Pay for repairs of any damage to any part of the project caused by defects in workmanship and installation. Pay for any repairs to materials or equipment caused by replacement. All repairs shall to be done to the satisfaction of the LANDSCAPE ARCHITECT.

C. Any part of the work installed under this contract requiring excessive maintenance will be considered as being defective. Replace defective items during the one year guarantee period at no cost to the Owner.

PART 2 - PRODUCTS

2.1 BIKE RACK

A. Manufacturer: Provide bicycle racks manufactured by DERO BIKE RACK CO., 42 Northern Stacks Drive, Suite 100, Minneapolis, MN 55421, 1-888-337-6729. Fax: 612-331-2731 Website: www.dero.com

B. Cornell Standard Bike Rack

1. Materials:

a. 2 3/8” Schedule 40 Pipe.

b. Installation Method: In-ground mount is embedded into concrete base.

2. Finishes:

a. A hot-dipped galvanized and PVC Dip, BLACK finish

b. Warranty:

c. Bicycle racks carry a one year manufacturer’s limited warranty against defects in materials and workmanship. The one year warranty period begins the date the product is shipped from the manufacturer.

2.2 BENCH (Install Only – Bench Provided by University)

2.3 ITEMS FABRICATED UNDER OTHER SECTIONS AND INSTALLED UNDER THE WORK OF THIS SECTION

A. Copper Alloy Handrail - Copper Alloy Handrail fabricated and delivered under the work of Section 055200 Miscellaneous Site Metal Fabrications

B. Stainless steel, carbon steel and galvanizing in accordance with the requirements of Section 055200 Miscellaneous Site Metal Fabrications.

2.4 CONCRETE

A. Concrete footings in accordance with the requirements of Section 033001 Cast-in-Place Concrete – Site.

2.5 GROUT

A. Grout as required for anchoring pins into concrete foundations shall be a pourable, quick setting, non-metallic and non-shrinking hydraulic cement grout equal to the following:

1. Five Star Grout
   U.S. Grout Corporation
   425 Stillson Road
   Fairfield, CT 06430
   (800) 243-2206
2. Sika Grout 212
   Sika Corporation
   Lyndhurst, NJ 07071
   (201) 933-8800
3. Harris Construction Grout
   AH Harris & Sons
   10 West Mill St.
   Medfield, MA 02052
   (508) 359-7321

2.6 SEALANTS

A. In accordance with the requirements of Division 07 Section Joint Sealants - Site.

2.7 ANCHORS

A. Stainless steel threaded anchors for furniture attachment shall be AISI Type 304 conforming to the requirements of ASTM A193M-99A, Identification Symbol B8 or B8A.

PART 3 - EXECUTION

3.1 INSPECTION

A. Prior to installation of any of the work in this Section, inspect the planned installation locations to insure that conditions are not significantly different from those indicated on the Contract Documents. Inspect all materials prior to installation to insure compliance with the Contract Documents and to insure there is no damage. Should conditions be different from those indicated on the contract documents, contractor shall immediately notify the LANDSCAPE ARCHITECT.

3.2 PREPARATION

A. Stake alignment and locations for all site furnishings for review and approval by LANDSCAPE ARCHITECT. Verify that all elements in this section “fit” within location provided.

B. Install items rigid, plumb and true to lines and levels shown.

C. Assemble (if required) and install items as per manufacturer’s printed instructions, unless otherwise specified or shown.

3.3 CONCRETE FOUNDATIONS AND SLABS

A. Install in accordance with Section 033001 Cast-in-Place Concrete - Site.

3.4 BIKE RACK

A. Install bike rack in locations as indicated and as directed by the LANDSCAPE ARCHITECT. Install level and plumb in accordance with manufacturer’s written instructions.

3.5 BENCH (Install Only – Bench Provided by University)

A. Install bench in locations as indicated and as directed by the LANDSCAPE ARCHITECT. Install level and plumb in accordance with manufacturer’s written instructions.

3.6 COPPER ALLOY HANDRAIL

A. Install level and plumb in the locations indicated, in accordance with the detailed drawings and as directed by the Landscape Architect.

B. Attachment to granite stair treads, concrete stair foundations and concrete pavement utilizing specified grout and sealant systems noted in this Section.

C. Seal joints between escutcheon plates and surrounding granite and concrete with approved sealant.

3.7 ACCEPTANCE STANDARDS

A. The LANDSCAPE ARCHITECT will reject delivered or installed site furnishing items for the following reasons:

1. Upon installation horizontal or vertical curves do not meet the shapes and profiles shown on the Contract Documents. Curves that have broken backs, sags, saddles, tangents or kinks will be rejected.

2. Items not level or plumb.
3. Fabricated items show metal pieces that were not accurately saw cut and were not fitted together. Gaps, spaces, voids, breaks and crooks in arris lines, humps, bumps, sags and saddles are present.
4. Sections are not well formed and do not meet the shapes and sizes indicated on the Contract Documents.
5. Exposed surfaces do not have a smooth finish and show surface differentiation and variation. Edges show nicks, grind marks or machine marks.
6. Anchorage into concrete or masonry is not solid but is perceptibly loose. Anchorage does not meet the requirements of the Contract Drawings.

END OF SECTION 323000

Section 32 91 13

PLANTING SOIL

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Requirements set forth herein are in addition to and shall be considered as complementary to the Terms and Conditions for Construction and the balance of Divisions 00 and 01 and Technical Specifications.

B. All Contractors, Subcontractors, Vendors and the like shall be required to familiarize themselves with said provisions.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for providing and installing planting soils, including but not limited to the following:

1. Soil material acquisition.
2. Testing and analysis of soils as indicated for conformance to the specification
3. Preparation of planting soil and testing for conformance
4. Coordination with other contractors

B. Related Requirements:

1. Section 329119 LANDSCAPE GRADING: installation of Planting Soil
2. Section 329200 TURF AND GRASSES
3. Section 329300 PLANTING
4. Section 329600 TRANSPLANTING.

1.3 REFERENCES

A. ASTM

1.	D422	Standard Test Method for Particle-Size Analysis
2.	D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
3.	D1556	Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
4.	D2167	Standard Test Method for density and Unit Weight of Soil in Place by the Rubber Balloon Method
5.	D4427	Standard Classification of Peat Samples by Laboratory Testing
6.	D5856-15	Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter
7.	D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
8.	F1647	Standard Test Methods for Organic Matter Content of Athletic Field Rootzone Mixes

9. F2396 Standard Guide for Construction of High Performance Sand-Based Rootzones for Athletic Fields

B. US EPA Class A standard, 40CFR § 503.13, Tables 1 and 3 levels Chemical Contaminants mg/kg (ppm)

C. NAPT: The North American Proficiency Testing Program

D. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

E. SSSA: Soil Science Society of America.

1.4 DEFINITIONS

A. Soil Definitions:

1. Soil Peds: Soil peds are natural, relatively permanent aggregates, separated from each other by voids or natural surfaces of weakness. If undisturbed, soil peds will persist through cycles of wetting and drying and freezing and thawing.
2. Topsoil: on-site or off-site surficial soil that exhibits biological growth, including root growth from plants, insects, worms, etc.
3. Planting Soil: amended topsoil meeting the requirements of this Section and used to grow turf, herbaceous plants or woody plants under the work of the Related Requirements noted in this Section.

1.5 ACTION SUBMITTALS: SOIL TESTING

A. General:

1. Submit On-site Topsoil, Off-site Topsoil, Planting Soil, Horticultural Subsoil, Compost, Coarse Sand, Gravel and Crushed Stone for testing at least 12 weeks before scheduled installation of Planting Soil. These soil components are part of an integrated system. Submit all test results as a single submission. If submitted individually then the Owner's Representative will take NO action until all other soil test results are submitted.
2. Do not order or deliver any soils, components or amendments until submittals have been returned "No Exceptions Taken". Said action by the Owner's Representative does not constitute final acceptance. The Owner's Representative reserves the right to reject any material delivered to the site, stockpiled for use on the site, or moved and spread anywhere on the site, that does not meet the requirements of this Specification.
3. Recognize these submittals are time-critical. Do not delay in organizing and making the submittals as specified. The testing protocols and iterative resubmissions shall be considered long lead-time items. Failure to make submittals on a timely basis shall constitute failure to meet project requirements.
4. Testing shall be at the Contractor's expense. Deliver all samples to the Testing Laboratories and to the Owner's Representative by overnight delivery and assume all costs.
5. Testing reports shall be sent directly to the Owner's Representative.

B. Testing Agencies:

1. Testing for mechanical gradation, chemical analysis carbon/nitrogen ratio, organic content, pH, salinity and nutrient content: UMass, West Experiment Station, Amherst, MA 01003, tel:413-545-2311 or approved equal agency capable of performing tests as specified in Northeastern Regional Publication No. 493, 3rd Edition as noted below.

C. Perform soil tests and provide test reports for Sand, Existing Topsoil and Planting Soil meeting the following requirements:

D. Comprehensive Particle Size Analysis:

1. On-site Topsoil, Off-site Topsoil, Planting Soil, Horticultural Subsoil, Sand and Existing On-site Subsoil: Determine soil texture in accordance with USDA Textural Classification System by combined Hydrometer Analysis for silt and clay, and dry sieving of sands. Standard Sieve sizes shall be used: No. 10, 18, 35, 60, 140 and 270 (2.00 mm, 1.00 mm, 0.50 mm, 0.25 mm, 0.10 mm, 0.05 mm). For particle sizes less than No. 270 (0.05 mm), testing in accordance with ASTM D422, Hydrometer method.
2. For Gravel and coarse sands: Determine the particle sizes in accordance with AASHTO requirements. Standard Sieve sizes shall be 2 in., 1-1/2 in., 3/4 in., 1/2 in., 3.8 in., No. 4, No. 8, No. 16, No. 30 (50 mm, 375 mm, 19 mm, 12.5 mm, 10.0 mm, 4.75 mm, 2.36 mm, 1.18 mm, 0.600 mm), testing in accordance with AASHTO T27.
3. For On-site Topsoil, Off-site Topsoil, Planting Soil, Horticultural Subsoil, Sand and Existing On-site Subsoil:
   a. Soil Ph (Soil acidity): Ph by SMP method in accordance with Northeastern Regional Publication No. 493, 3rd Edition, Chapter 3.
   b. Cation Exchange Capacity (CEC): by Compulsive Exchange
   c. Soluble Salts: Extract Method for air-dried samples of 1-part Soil to 2-parts Water (1:2 volume to volume), in accordance with the requirements of Northeastern Regional Publication No. 493, 3rd Edition, Chapter 10. Submit as mmhos/cm (Ds/m)
4. Organic Content of On-site Topsoil, Off-site Topsoil, Planting Soil and Horticultural Subsoil:
   a. Loss of Weight on Ignition, (LOI) in accordance with Northeastern Regional Publication No. 493, 3rd Edition, Chapter 8.

      $$LOI(\%) = \frac{(\text{WEIGHT AT } 105^{OC} - \text{WEIGHT AT } 360^{OC}) \times 100}{\text{WEIGHT AT } 105^{OC}}$$

      AND

   b. ASTM F1647 Standard Test Methods for Organic Matter Content of Athletic Field Rootzone Mixes Loss on Ignition at 360 +/- 10Oc, which is same testing procedure as described.
5. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.

E. For Compost

1. Comprehensive Compost Tests, including:
   a. pH
   b. Electrical Conductivity (mmhos/cm (Ds/m)
   c. Bulk Density
   d. Percent Solids
   e. Organic Matter (LOI)
   f. Total Nitrogen
   g. Organic Nitrogen
   h. Nitric Nitrogen
   i. Total Carbon
   j. Carbon: Nitrogen (C:N) ratio
   k. Total Phosphorus, Potassium, Calcium, Magnesium

F. Phytotoxicity: Test for plant-available concentrations of phytotoxic minerals including aluminum, arsenic, barium, cadmium, chlorides, chromium, cobalt, copper, lead, lithium, mercury, nickel, selenium, silver, sodium, strontium, tin, titanium, vanadium, and zinc.

1.6 ACTION SUBMITTALS – SAMPLES

A. Samples: For compost, On-site Topsoil, Off-site Topsoil and Planting Soil, submit to the Owner's Representative a 2-gallon volume in sealed containers labeled with the content, source and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

1. Provide a two-gallon sample from each source with required soil testing results. The sample shall be a mixture of the random samples taken around the source stockpile or field.
2. For topsoil and planting soil samples: Samples shall be delivered with soil peds intact that represent the size and quantity of expected peds in the final delivered soil.
3. Submit sources for coarse sand, gravel, compost, topsoil and Planting Soil. The Owner's Representative shall have the right to reject any source of these materials without recourse by the Contractor.

B. Product Data: provide the most recent product information from manufacturer for:

1. Compost: identify the material from which the compost was made and identify the location where the material was composted.

1.7 INFORMATIONAL SUBMITTALS

A. Qualifications of Supplier of Soil Components and Manufacturer of Planting Soil:

1. Submit name, address, telephone number and contact name of supplier/manufacturer with certification that same has requisite 5-years' experience as specified.
2. Submit certification that the supplier/manufacturer will be able to provide required volumes of soil components and blended soil mixes for the entire project.
3. The Owner's Representative and the Owner will have the right to reject any supplier/manufacturer without explanation to or appeal by the Contractor.
4. Provide alternative supplier/manufacturer as directed by the Owner's Representative.

B. Qualification Data: For each testing agency, demonstrate in writing that the testing agency is NAPT-affiliated, can perform the specified tests in accordance with the specified testing procedures.

1.8 PRE-INSTALLATION MEETING

A. In accordance with the requirements of Section 329119 LANDSCAPE GRADING: At least 30 days prior to delivery of planting soil to the site, conduct a meeting to review: status of submittals; coordination of work; methods of delivery, storage, mixing and spreading of soils; and inspections and testing.

B. Attendees: Include but not limited to General Contractor; Landscape subcontractors; Owner's Representative and Owner.

C. Minutes of the meeting: Contractor shall take minutes and type and distribute the minutes to attendees within five days of the meeting.

1.9 QUALITY ASSURANCE - GENERAL

A. Source of supply for Soil Components and Planting Soil:

1. Suppliers of soil components and planting soil shall have a minimum of 5-years' experience at supplying and manufacturing custom planting soil mixes.

1.10 QUALITY ASSURANCE – TESTING AGENCY

A. Testing Agency Qualifications: Agricultural soil testing laboratory, NAPT –participating, independent, State-operated or university-operating laboratory experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

B. Soil Test Agency shall utilize the following soil test procedures and methods by region:

1. Northeastern United States: Recommended Soil Testing Procedures for the Northeastern United States, Northeastern Regional Publication No. 493, 3rd Edition. Agricultural Experiment Stations of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and West Virginia.

C. Perform percolation testing of the prepared subgrade every 10,000 square feet. After subgrade levels have been reached, the Contractor and the Owner's Representative will inspect soil conditions together to evaluate subsurface drainage conditions. Locations where percolation rates are less than 1.0 inch per hour shall be deep de-compacted, recompressed and re-tested. If the subgrade fails to drain adequately after re-work, installation of drain lines or other mitigation measures may be required.

1.11 SOIL-SAMPLING REQUIREMENTS

A. Sampling shall be done by the Contractor. The size of the samples and method of sampling shall be as follows: Samples shall be representative of the material to be brought to the site. Each sample shall be a Composite Sample, which consists of 8

separate sub samples taken from a minimum of 8 different locations at each source and mixed together to make the test sample.

1. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its records.
2. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.12 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Protect materials from theft, damage, weather, dirt, oils, grease, and construction activities.

C. Sequence deliveries to avoid delay. On-site storage space is permissible only with written notice from the Owner. Deliver materials only after preparations for placement of planting soil have been completed.

D. Prohibit vehicular and pedestrian traffic on or around stockpiled planting soil.

E. Vehicular access to the site is restricted. Before construction, the Contractor shall submit for approval a plan showing proposed routing for deliveries and site access.

F. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

G. On-site Topsoil, Off-site Topsoil, horticultural subsoil and compost:

1. Stockpile in windrows less than six feet high and no longer than ten days before placement or use.
2. Cover during precipitation events to minimize saturated soil conditions. Do not manipulate when in a wet or frozen condition, to include planting operations.

1.13 PROJECT/SITE CONDITIONS - IN ACCORDANCE WITH SECTION 319119 LANDSCAPE GRADING

PART 2 - PRODUCTS

2.1 EXISTING ON-SITE TOPSOIL

A. The topsoil excavated during site preparation may be stockpiled for testing and reuse, provided the soil can be stripped and stockpiled in a single location, properly windrowed, and left in place until the time of amendment and spreading. If these conditions cannot be met then remove and discard off site. Existing topsoil may be used as a planting soil mix or as a component of manufactured planting soil mixes provided it meets all criteria specified in this Section.

B. The Owner does not stipulate that there will be sufficient on-site topsoil to meet the specified requirements, needs, soil depths or soil volumes specified in these Specification Sections. Nor does the Owner stipulate that the existing on-site topsoil can be stockpiled on site for the duration of the project and serve the purposes and requirements of this Section.

C. If retained on site for possible reuse, test on-site stockpiled topsoil to determine Soil Texture, Soil pH, CEC, Soluble Salts, Organic Content.

D. Test existing on-site topsoil directly west of the existing building as specified in this section.

2.2 TOPSOIL

A. Topsoil: Fertile, friable soil suitable for the germination of seeds and the support of vegetative growth. Imported Topsoil shall not contain weed seeds in quantities that cause noticeable weed infestations in the final planting beds. Imported Topsoil shall meet the following physical and chemical criteria:

B. Soil texture: USDA sandy loam, fine sandy loam, loam, or sandy clay loam

1. Loam borrow shall have the following mechanical analysis:

TEXTURAL CLASS	% OF TOTAL WEIGHT	AVERAGE %
Sand (0.05 - 2.0 mm dia. range)	45 - 75	60
Silt (0.002-0.05 mm dia. range)	15 - 35	25
Clay (less than 0.002 mm dia. range)	5 - 20	15

   a. The maximum size of particles shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 15 percent by weight of the total sample.
2. pH value shall be between 5.5 and 7.0.
3. Percent organic matter (OM): 2.0-5.0-percent, by dry weight.
4. Soluble salt level: Less than 1 mmho/cm.
5. Soil chemistry suitable for growing the plants specified.
6. The organic content and particle size distribution shall be the result of natural soil formation.
7. Soil shall have an observable crumb and clod structure. Soil crumbs (peds) and clods shall be the same color on the inside as are visible on the outside.

C. Topsoil shall be a harvested soil from:

1. Naturally well-drained areas that have never been stripped before and have a history of satisfactory vegetative growth. Comply with all Town, City and State lawns and regulations concerning the removal of topsoil from their boundaries.
2. On-site topsoil stripped, stockpiled and paid for under the work of this Contract.
3. A commercial processing facility specializing in the manufacturing of loam.

D. Topsoil shall NOT have been screened and shall retain soil peds or clods larger than 2 inches in diameter throughout the stockpile after harvesting.

E. Topsoil shall not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass, and all other primary noxious weeds. Topsoil shall not be delivered or used for planting while in a frozen or muddy condition.

F. Topsoil shall be free of concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.

G. It shall be free of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.

H. The maximum size of any stone, clay lumps or roots shall not exceed 2-inches largest dimension

I. The existing topsoil may be acceptable for use on this project provided it meets the above acceptance criteria. Take samples of the existing topsoil, test in accordance with the requirements of this Section and submit soil test reports for review and approval by the Owner's Representative.

2.3 COARSE SAND

A. Uniformly graded medium to coarse sand consisting of clean, inert, natural grains of quartz or other durable rock that is free of toxic and deleterious materials harmful to plant growth. Sand shall have the following characteristics.

1. Coefficient of uniformity (D70/D20) for material passing the No. 10 Sieve shall be <3
2. pH < 7.0
3. Containing no calcium carbonate
4. USDA Silt fraction < 2.5 percent
5. USDA Clay fraction < 0.5 percent

B. ASTM C-33 Fine Aggregate with the following particle size distribution.

Sieve	Sieve Size	% Passing
3/8-inch	9.50 mm	100
1/4-inch	6.30 mm	96 - 100
No. 10	2.00 mm	82 - 98
No. 18	1.00 mm	50 - 80
No. 35	0.500 mm	20 - 53
No. 60	0.250 mm	28 - 61
No. 140	0.100 mm	6.5 - 35
No. 270	0.050 mm	0 – 2.5
	0.002 mm	0 – 0.5

2.4 COMPOST

A. Compost used to amend planting soils and for topdressing beds shall be an aerobically decomposed, stable, mature, humus-like material free of debris, stones greater than 0.5-inch, metal, plastics, wood and similar inert or unwelcome contaminants.

B. It shall be commercially prepared, meeting US Compost Council STA/TMECC criteria or as modified in this section for “Compost as a Landscape Backfill Mix Component”. Refer to. http://compostingcouncil.org/admin/wp-content/plugins/wp-pdfupload/pdf/191/LandscapeArch_Specs.pdf.

1. Compost shall be deep brown or darker color and intended by the manufacturer for ornamental planting purposes.
2. It shall have been screened to remove all particles >0.50 inches. 90 to 100 percent shall pass a 3/8-inch screen.
3. It shall not have an unpleasant odor as determined by sniff test of submitted samples.
4. The ratio of carbon to nitrogen (C:N ratio) shall be between 15:1 and 25:1.
5. Salinity shall not exceed 2.0 dS/m (2.0 mmhos/cm)
6. pH: Between 6 & 8
7. Minimum organic content of 35 percent by weight.
8. Chemical contaminants, mg/kg (ppm): meet or exceed US EPA Class A standard, 40CFR § 503.13, Tables 1 and 3 levels.
9. Biological contaminants select pathogens fecal coliform bacteria, or salmonella, meet or exceed US EPA Class A standard, 40 CFR § 503.32(a) level requirements.
10. Moisture content: wet weight basis 30 – 60 percent.

2.5 PLANTING SOIL MIXES FOR SPECIFIC USES

A. Planting soil for the top 18-inches of the soil profile for planting trees, shrubs, groundcover, perennials and other ornamental plants may be approved topsoil or a blended mix of approved coarse sand, topsoil and compost meeting the following requirements:

1. The ratio of the particle size for 80 percent passing (D80) to the particle size for 30-percent passing (D30) shall be 15 or less. (D80/D30 < 15).
2. Maximum size shall be 2-inches largest dimension. The maximum retained on the #10 sieve shall be 15-percent by weight of the total sample.
3. The organic content shall be between 5 and 8 percent by weight

4. Saturated hydraulic conductivity of the mix: not less than 2 inches per hour according to ASTM D5856 when compacted to a minimum of 86% Standard Proctor, ASTM 698
5. pH: 5.5 through 6.5 for non-acid loving plants
6. pH: 4.5 through 5.5 for Ericaceae and other acid-loving plants

B. Where the Drawings require the approved topsoil to be underlain with horticultural subsoil, the horticultural subsoil shall be the approved planting soil amended with coarse sand and having reduced organic content meeting the following requirements:

1. The ratio of the particle size for 80 percent passing (D80) to the particle size for 30-percent passing (D30) shall be 6 or less. (D80/D30 < 6).
2. Maximum size shall be 2-inches largest dimension. The maximum retained on the #10 sieve shall be 15-percent by weight of the total sample.
3. The organic content shall be between 1 and 2 percent by weight
4. Saturated hydraulic conductivity of the mix: not less than 5 inches per hour according to ASTM D5856-95 (2000) when compacted to a minimum of 86% Standard Proctor, ASTM 698.
5. pH: 5.5 through 6.5 for non-acid loving plants
6. pH: 4.5 through 5.5 for Ericaceae and other acid-loving plants

C. Planting soil for general lawn areas may be approved topsoil or a blended mix of approved coarse sand, topsoil and compost meeting the following requirements:

1. The ratio of the particle size for 80 percent passing (D80) to the particle size for 30-percent passing (D30) shall be 10 or less. (D80/D30 < 10).
2. Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 20-percent by weight of the total sample.
3. The organic content shall be between 2.5 and 4-percent by weight
4. Saturated hydraulic conductivity of the mix: not less than 2 inches per hour according to ASTM D5856-95 (2000) when compacted to a minimum of 86% Standard Proctor, ASTM 698

D. Planting soil shall be pH adjusted for particular planting applications and shall be adjusted prior to delivery to the Project sites as recommended by soil test results.

1. Use sulfur or ferrous sulfate to adjust pH downward to required levels.
2. When pH of planting soil must be raised to the required levels use limestone.
3. Regardless of amendment Contractor chooses to use, Contractor, not the Owner, shall be responsible for obtaining specified pH by seeding and/or planting time.

2.6 INORGANIC SOIL AMENDMENTS USE AS APPLICABLE:

A. Ground Limestone: dolomitic limestone containing not less than 50 percent of total carbonates and 25 percent total magnesium with a neutralizing value of at least 100 percent. Material shall be ground to such fineness that 40 percent will pass 100 mesh U.S. standard sieve and 98 percent will pass through 20 mesh U.S. standard sieve.

B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 sieve and a maximum of 10 percent passing through a No. 40 sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur. Chelated Iron: Commercial-grade FeEDDHA (ethylenediamine-N,N'-bis(2-hydroxyphenylacetic acid) or dicots and woody plants, and commercial-grade FeDTPA (Diethylene Triamine Penta Acetic Acid Iron) for ornamental grasses and monocots.

2.7 FERTILIZERS

A. Pre-Plant Fertilizer

1. Complete, fertilizer made from all-natural ingredients complying with State and Federal fertilizer laws. Fertilizer shall contain the following available plant food by weight, unless soils test indicate a need for different composition:

	Nitrogen	Phosphorus	Potash
Deciduous Trees and Shrubs	2%	3%	3%
Evergreen Trees and Shrubs	2%	3%	3%

B. Fertilizer: Pro Start 2-3-3 manufactured by North Country Organics, Bradford, Vermont 05033, ph# 802.222.4277 or approved equal.

C. Fertilizer shall be delivered in original unopened standard size bags showing weigh, analysis ingredients and manufacturer's name.

PART 3 - EXECUTION

3.1 TRANSPORT AND DELIVERY

A. The Contractor shall provide sufficient topsoil, planting soil, coarse sand and compost to complete the work of the Contract.

B. Locate, procure and delivery soils and soil components sufficiently in advance of earthwork and earth moving activities, landscape grading, planting and turf establishment to meet Project schedules.

C. Deliver soils and soil components to the Project site in tarpaulin-covered trucks. Stockpile in locations approved by the Owner's Representative.

D. Stockpiled soil and aggregate materials shall be protected from erosion and sedimentation in accordance with the relevant provisions of Section TEMPORARY EROSION AND SEDIMENTATION CONTROLS of this Specification.

E. Coordinate the stockpiling of soils and soil components with the work of Section 32 9119 LANDSCAPE GRADING

3.2 NOTIFICATION

A. Notify the Owner's Representative when the soils and soil components are scheduled for delivery and schedule his/her attendance on site to witness delivery and stockpiling. The Owner's Representative will inspect the soils and soil components for conformance to the requirements of the Contract.

3.3 INSTALLATION

A. Install existing on-site stockpiled topsoil, planting soil, coarse sand and compost in accordance with the requirements of Section 32 9119 LANDSCAPE GRADING.

3.4 CLEANUP

A. In accordance with requirements of Section 32 9119 LANDSCAPE GRADING.

END OF SECTION

Section 32 91 19

LANDSCAPE GRADING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Requirements set forth herein are in addition to and shall be considered as complementary to the Terms and Conditions for Construction and the balance of Divisions 00 and 01 and Technical Specifications.

B. All Contractors, Subcontractors, Vendors and the like shall be required to familiarize themselves with said provisions.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for installing planting soils, including but not limited to the following:

1. Inspection and testing of subgrade, as specified and directed
2. De-compaction and re-compaction of soils, as directed
3. On site transport of topsoil, planting soil, coarse sand and compost as required to fulfill the requirements of the Contract.
4. Placement of topsoil and planting soil
5. Soil amendments as required to meet the requirements of Section 329113 PLANTING SOILS and this Section 329119.
6. Final in-place testing of soils as directed
7. Coordination with other contractors
8. Clean up.

B. Related Requirements:

1. Section 32 9113 PLANTING SOILS for planting soil standards
2. Section 32 9200 TURF AND GRASSES for placing planting soil for turf and grasses.
3. Section 32 9300 PLANTS for placing planting soil for plantings.
4. Section 32 9600 TRANSPLANTING for placing planting soil in tree planting pits.

1.3 REFERENCES

A. ASTM

1.	D422	Standard Test Method for Particle-Size Analysis
2.	D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
3.	D1556	Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
4.	D2167	Standard Test Method for density and Unit Weight of Soil in Place by the Rubber Balloon Method
5.	D5856-15	Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter

6. D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
7. F1647 Standard Test Methods for Organic Matter Content of Athletic Field Rootzone Mixes
8. F2396 Standard Guide for Construction of High Performance Sand-Based Rootzones for Athletic Fields

B. NAPT: The North American Proficiency Testing Program

1.4 DEFINITIONS

A. Soil compaction: the formation of dense layers of overly packed soil. Compaction will force soil particles closer together, driving out pore space and reducing the volume of air and water in soil. Compaction seals off the soil surface and reduces the amount of air and water that enters the soil. Compaction reduces and can eliminate the movement of water and air through the soil, preventing the movement of plant roots through the soil and creating anaerobic conditions that will kill plant material and turf.

B. Under the terms of this Contract, there are no acceptable remediation efforts that can return compacted loam borrow, existing on-site topsoil or horticultural subsoil to a useful product.

C. Compacted planting soil system components will be considered debris.

D. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or un-amended soil as indicated.

E. Soils:

1. Sub-grade/subsoil: Existing native soil in cut, on-site topsoil in fill conditions, or imported soils in fill conditions as part of the planting soil system.
2. Soil Peds: Soil peds are natural, relatively permanent aggregates, separated from each other by voids or natural surfaces of weakness. If undisturbed, soil peds will persist through cycles of wetting and drying and freezing and thawing.
3. Dry Soil: Soil that has dried out is characterized by rigidity, brittleness and maximum resistance to pressure. When pressure is applied to dry soil, it has a tendency to crush to a powder or to fragments. Soil that is crushed may not have the ability to cohere again when it is wetted and pressed back together. Soil that is crushed when dry and rewetted may lose its crumb structure. A soil that has lost its crumb structure due to applied pressure when it has been dried has failed.
4. Wet Soil: When soil becomes saturated, water fills the large and medium sized pores between the peds. Left to drain, the integrity of the soil structure remains intact. When pressure is applied to wet soil the ped structure breaks down and the mineral and organic components mix into a water-and-soil slurry. . Without exception under the terms of this Contract, saturated topsoil and planting soil subject to pressure is reduced to mud.
5. Mud: A soft, sticky matter resulting from the mixing of soil and water under pressure. Mud is construction debris that cannot be amended or ameliorated to return to functional use.
6. Debris Soils: Compacted topsoil and planting soils, wet soils that have been subjected to pressure and mud are considered debris under the terms of this Contract. Sticks, stones, trash, rubbish and any broken construction materials are also considered debris under the terms of this Contract. Any material identified by

the Owner's Representative as unwanted or unsuitable to the site shall be considered debris.

F. Subsoiling: The vertical and lateral fracturing of compacted subsoil material to full depth of compaction through deep ripping and de-compaction to restore soil porosity and permeability, to aid in infiltration of water, and to promote root growth.

G. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within building lines.

1.5 ACTION SUBMITTALS: SOIL TESTING

A. General: as specified under Section 329113 PLANTING SOILS.

B. When directed by the Owner's Representative, sample and test (amended topsoil) (amended planting soil). Sampling and testing requirements shall be in accordance with the requirements of Section 329113 PLANTING SOILS.

1.6 ACTION SUBMITTALS

A. Product Data: provide the most recent product information from manufacturer for:

1. Fertilizer
2. Ground limestone
3. Superphosphate
4. Penetrometer

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency, demonstrate in writing that the testing agency is NAPT-affiliated, can perform the specified tests in accordance with the specified testing procedures.

B. Certification by the General Contractor and/or sub-contractor responsible for earth moving work that the soils have been de-compacted.

C. Percolation testing by testing laboratory. Provide percolation test results for review and approval.

1.8 PRE-INSTALLATION MEETING

A. General: At least 30 days prior to delivery of bulk materials and amendment materials to the site, conduct a meeting to review: status of submittals; coordination of work; methods of delivery, storage, amending soils; and inspections and testing.

B. Attendees: Include but not limited to Contractor; Landscape subcontractors; Owner's Representative and Owner.

C. Minutes of the meeting: Contractor shall take minutes and type and distribute the minutes to attendees within five days of the meeting.

1.9 QUALITY ASSURANCE - GENERAL

A. Inspections: Do not spread planting soil until:

B. Contractor has performed requirements of Soil Installation Mockup.

C. Contractor has certified in writing the subgrade infiltrates water at the minimum specified rate.

1.10 QUALITY ASSURANCE – PLANTING SOIL INSTALLER

A. The Landscape Contractor shall be the same firm that is installing planting and establishing turf as described in respective Division 32 Sections.

B. The Landscape Contractor shall be a firm having at least 5 years of successful experience of a scope similar to that required for the Work, including mixing and amending topsoil in a manner that does not destroy soil structure.

C. Installer Field Supervision: Installer to maintain an experienced full-time supervisor on Project site when any topsoil amendment work is in progress.

D. The Landscape Contractor's crew shall be experienced in the amendment and installation of planting soil, grading and interpretation of grading plans.

E. Soil work shall be performed by a firm that has sufficient earthwork machinery at the job site to execute the site work without interruption or delay, except for unforeseen circumstances, such as weather. Machinery operators shall be well experienced in this type of work without limitation to topography or existing conditions to be protected.

F. Comply with applicable requirements of the laws, codes, ordinances and regulations of Federal, State and municipal authorities having jurisdiction. Obtain necessary approvals from all such authorities.

1.11 QUALITY ASSURANCE – TESTING AGENCY

A. Perform percolation testing of the prepared subgrade every 2,500 square feet. Prior to placement of planting soil, the Contractor and the Owner's Representative will inspect subgrade conditions together to evaluate subsurface drainage conditions. Carry out percolation tests in accordance with the requirements of this Section in locations identified by the Owner's Representative. Locations where percolation rates are less than 1.0 inch per hour shall be deep de-compacted, recompressed and re-tested in accordance with the requirements of this Section. If the subgrade fails to drain adequately after re-work, installation of drain lines or other mitigation measures may be required.

1.12 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Protect materials from theft, damage, weather, dirt, oils, grease, and construction activities.

C. Sequence deliveries to avoid delay. On-site storage space is permissible only with written notice from the Owner.

D. Vehicular access to the site is restricted. Before construction, the Contractor shall submit for approval a plan showing proposed routing for deliveries and site access.

E. Bulk Materials:

1. Stockpile in windrows less than six feet high and no longer than ten days before placement or use.
2. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
3. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
4. Do not move or handle materials when they are wet or frozen.
5. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

F. Compost:

1. Stockpile in windrows less than six feet high and no longer than ten days before placement or use.
2. Cover during precipitation events to minimize saturated conditions. Do not manipulate when in a wet or frozen condition, to include planting operations.

1.13 PROJECT/SITE CONDITIONS

A. Soil Moisture Content

B. Do not amend, spread or manipulate planting soils when moisture content is so great that adequate mixing or management are not possible, nor when it is so dry that dust will form in the air or that clods will not break readily, nor when it is frozen. Apply water, if necessary, or allow soil to dry to bring soil moisture between 60% of optimum moisture content and optimum moisture con-tent as determined by ASTM D698 for compaction, grading and plantings.

C. Soil may not be manipulated in any way while in a wet condition, including amending, fine grading, planting or any other excavation. Contractor is responsible for removal and replacement of any and all soils that were manipulated when wet.

D. Field Soil Moisture Test

1. Form soil in palm of hand, if soil retains shape and crumbles upon touching, the soil may be worked.
2. If the soil will not retain shape it is too dry and should not be worked.
3. If the soil retains shape and will not crumble, it is too wet and should not be worked.
4. If the soil glistens or free water is observed when the sample is patted in the palm of hand the soil is too wet and should not be worked.

PART 2 - PRODUCTS

2.1 TOPSOIL AND PLANTING SOIL

A. Specified and delivered under the work of Section 329113 PLANTING SOILS.

B. Topsoil and planting soil shall NOT be amended or manipulated in any manner that might alter, damage or destroy the soil's existing structure. Retain soil peds or clods larger than 2 inches in diameter throughout the amendment process.

2.2 COARSE SAND – IN ACCORDANCE WITH THE REQUIREMENTS OF SECTION 329113 PLANTING SOIL.

2.3 COMPOST– IN ACCORDANCE WITH THE REQUIREMENTS OF SECTION 329113 PLANTING SOIL.

2.4 INORGANIC SOIL AMENDMENTS - AS SPECIFIED UNDER SECTION 329113 PLANTING SOILS.

2.5 FERTILIZERS

A. Pre-Plant Fertilizer

B. Complete, fertilizer made from all-natural ingredients complying with State and Federal fertilizer laws. Fertilizer shall contain the following available plant food by weight, unless soils test indicate a need for different composition:

	Nitrogen	Phosphorus	Potash
Deciduous Trees and Shrubs	2%	3%	3%
Evergreen Trees and Shrubs	2%	3%	3%

C. Fertilizer: Pro Start 2-3-3 manufactured by North Country Organics, Bradford, Vermont 05033, or approved equal, natural, non-burning, eco-compatible starter fertilizer.

D. Fertilizer shall be delivered in original unopened standard size bags showing weigh, analysis ingredients and manufacturer's name.

PART 3 - EXECUTION

3.1 SITE EXAMINATION

A. Prior to installation of Planting Soil, examine site to confirm that existing conditions are satisfactory for the work of this section to proceed.

1. Confirm that the subgrade is at the proper elevation and compacted as required.
2. Confirm that surface of all areas to be filled with Planting Soil are free of construction debris, refuse, compressible or biodegradable materials, stones greater than 2 inches diameter, soil crusting films of silt or clay that reduces or stops drainage from the Planting Soil into the subsoil; and/or standing water. Remove unsuitable material from the site.
3. Confirm that no adverse drainage conditions are present.
4. Confirm that no conditions are present which are detrimental to plant growth.

5. Confirm that utility work has been completed per the drawings.
6. Confirm that irrigation work, which is shown to be installed below prepared soil levels, has been completed.

B. If unsatisfactory conditions are encountered, notify the Owner's Representative immediately to determine corrective action before proceeding.

C. Proceed with placement of planting soil only after unsatisfactory conditions have been corrected.

3.2 PROTECTION

A. Protection Zone: Identify protection zones according to Section 015639 "Temporary Tree and Plant Protection."

B. Protect areas of in-place, existing topsoil from compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

3.3 FILLING AND COMPACTION

A. Perform percolation tests on existing subgrade or placed fill prior to placing and spreading loam borrow:

1. In accordance with the requirements of this Section, perform percolation testing of subgrade to confirm subgrade drains properly. Perform percolation tests as specified in this Section.
2. In the event that percolation testing indicates that the subgrade has been over compacted and does not drain adequately, loosen the subgrade to depths required to establish specified minimum infiltration rate. Loosen the soil by ripping or other mechanical method. Re-compact the subgrade as required to insure proper infiltration and to avoid future settlement. After the soil has been loosened and re-compacted, allow vehicle access only by approved tracked vehicles or low-ground-pressure vehicles.

B. Confirm that the subgrade is at the proper elevation and that no further earthwork is required to bring the subgrade to proper elevations to receive planting soil. Rough grade the subgrade so that it slopes parallel to the finished grade. Confirm in writing that the subgrade has been placed to the required elevations and that the subgrade drains freely.

C. Clear the subgrade of all construction debris, trash, rubble and any foreign material. In the event that fuels, oils, concrete washout or other material harmful to plants have been spilled into the subgrade material, excavate the soil sufficiently to remove the harmful material. Remove such construction debris, trash, rubble and foreign material from the

site and disposed of it in a legal manner. Fill any over excavation with approved fill and compact to the required subgrade compaction levels.

D. Do not proceed with the installation of planting soil until all utility work in the area has been installed.

E. Protect adjacent walls, walks and utilities from damage or staining by earthwork activities and placement of planting soil. Use plywood and or plastic sheeting as directed to cover existing concrete, metal and masonry work and other items as directed during the progress of the work. Clean up all trash and any soil or dirt spilled on any paved surface at the end of each working day.

3.4 PLACING AND AMENDING PLANTING SOIL

A. Coordinate the work of this Article with the work of Section 329300 PLANTING and Section 329200 SEEDED TURF.

B. Immediately prior to dumping and spreading planting soil, the subgrade shall be cleaned of all stones greater than 2 inches and all debris or rubbish. Such material shall be removed from the site, not raked to the edges and buried. Notify the Owner's Representative that the subsoil has been cleaned and request his/her attendance on site to review and approve subgrade conditions prior to spreading planting soil.

C. Place planting soil in two lifts. Place the first lift to a depth of 4 inches and harrow or till the planting soil into the underlying subsoil to a depth of 4 inches, creating a blended interface of planting soil and subsoil approximately 6 to 8-inches deep. Spread the second lift of planting soil to the depths shown on the Contract Documents.

D. Do not handle planting soil in any way if it is in an overly dry, wet or frozen condition.

E. Soil additives, including coarse sand, compost, amendments and fertilizer shall be spread and incorporated into the planting soil by methods that preserve the soil structure. Apply additives and amendments based on soil test results and discussion during the on-site, preconstruction conference.

F. At the direction of the Owner’s Representative and at no additional cost to the Owner, sample and test the installed planting soil in accordance with Section 329113 PLANTING SOILS, to verify additives and amendments have be correctly applied to meet specification requirements.

G. After planting soil and required additives and amendments have been spread, carefully prepare the planting soil by scarifying, harrowing, or tilling the planting soil to mix soil additives and amendments into the top 6 inches of the planting soil. Remove all brush, roots, stumps, litter and other foreign matter churned up by this mixing operation. Do not damage soil structure. Soil peds shall be readily visible after mixing operations.

3.5 FINE GRADING

A. Grade the finish surface of all lawn, turf and planted areas to meet the grades shown on the drawings, allowing the finished grades to remain higher (10 – 15% of depth of soil modification) than the grades on the grading plan, to anticipate settlement over the first year.

B. Utilize hand equipment, small garden tractors with rakes, or small garden tractors with buckets with teeth for fine grading to keep surface rough without further compaction. Do not use the flat bottom of a loader bucket to fine grade, as it will cause the finished grade to become overly smooth and or slightly compressed.

C. Provide for positive drainage from all areas toward the existing inlets, drainage structures and or the edges of planting beds. Adjust grades as directed to reflect actual constructed field conditions of paving, wall and inlet elevations. Notify the Owner's Representative in the event that conditions make it impossible to achieve positive drainage.

D. Provide smooth, rounded transitions between slopes of different gradients and direction. Modify the grade so that the finish grade before adding mulch and after settlement is one or two inches below all paving surfaces or as directed by the drawings.

3.6 COMPACTION

A. Set sufficient grade stakes to confirm finished grades. Set stakes in the bottom of swales and at the top of slopes. Deviation from indicated elevations that are greater than one-tenth of a foot shall not be permitted. Connect contours and spot elevations with an even slope. Finish grades shall be smooth and continuous with no abrupt changes at the top or bottom of slopes.

B. During the compaction process, all depressions caused by settlement or rolling shall be filled with additional planting soil and the surface shall be re-graded and rolled until presenting a smooth and even finish corresponding to the required grades.

C. Install planting soil in successive horizontal lifts no thicker than 6 inches in turf areas and 12 inches in plant bed areas to the compaction as described herein. The Owner's Representative will ensure that the full depths of planting soil for lawn and plant beds are obtained by digging holes in the loam borrow at the same frequency as for compaction testing.

1. Compact planting soil to the required density as specified herein.

   Maximum dry density for planting soil shall be determined in accordance with ASTM D698. The following percentages of minimum to maximum dry densities shall be achieved for fill materials or prepared subgrades.

   In lawn, plant beds, tree pits:

	Minimum	Maximum
Fills within lawn and planting areas in top eighteen inches of finished grade	80%	85%

2. The surface area of each lift shall be scarified by raking prior to placing the next lift.

D. In addition to the range cited above, compact each lift sufficiently to reduce settling but not enough to prevent the movement of water and feeder roots through the soil. The planting soil in each lift should feel firm to the foot in all areas and make only slight heel prints. At completion of planting soil installation, the soil should offer a firm, even resistance when the penetrometer is inserted from lift to lift.

E. All equipment utilized to install or grade planting soils or for access to subgrade soils or placed fills, shall be wide track or balloon tire machines rated with a ground pressure of 4 psi or less. All grading and soil delivery equipment shall have buckets equipped with 6 inch long teeth to scarify any soil that becomes compacted.

F. Phase work such that equipment to deliver or grade soil does not have to operate over previously installed Planting Soil. Work in rows of lifts the width of the extension of the bucket on the loader. Install all lifts in one row before proceeding to the next. Work out from the furthest part of each bed from the soil delivery point to the edge of the each bed area.

G. Where travel over installed planting soil is unavoidable, limit paths of traffic to reduce the impact of compaction to the planting soil. Each time equipment passes over the installed planting soil it shall reverse out of the area along the same path with the teeth of the bucket dropped to scarify the soil.

H. The depths and grades shown on the drawings are the final grades after settlement and shrinkage of the compost material. Install the planting soil at a higher level to anticipate this reduction of planting soil volume. A minimum settlement of approximately 10 - 15% of the soil depth is expected.

I. Maintain all stockpiles of planting soil and existing topsoil on the site until the Owner's Representative has approved finish grades. Upon written approval of finished grades, remove excess planting soil and topsoil from the construction site and relocate stockpiles to locations on the project property as directed by the Owner.

3.7 PERCOLATION TESTING OF SUBGRADE CONDITIONS

A. Prior to the placement of planting soil, perform percolation tests to determine if the subgrade or placed fills are overly compacted. Perform the following percolation test procedure:

1. Dig a hole in the subgrade or placed fills that is a minimum of 6 inches in diameter and 4-inches deep.
2. Fill the hole with water and let it drain completely. Immediately refill the hole with water and measure the rate of fall in the water level.
3. In the event that the water drains at a rate less than one-inch per hour, the soil is too compact to drain. Determine the depth of compaction as follows:
4. In the area of the first percolation test, excavate a square area measuring 60-inches on an edge to the 4-inch depth of the first hole (A.1 above). Dig a new hole and repeat the percolation test.
5. Repeat this procedure until a depth of free-draining soil has been reached.
6. De-compact the subgrade by ripping or turning the soil over by backhoe. De-compact to the full depth of compacted, poorly draining subgrade or placed fill. De-compact the soil to a depth required to break the over compaction.
7. Initially, perform a minimum of one soil percolation test per 10,000 square feet area of turf area and 2,500 square feet of tree and shrub planting area as directed by the Owner's Representative.

3.8 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

END OF SECTION

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Section 32 92 00

SEEDED TURF

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Requirements set forth herein are in addition to and shall be considered as complementary to the Terms and Conditions for Construction and the balance of Divisions 00 and 01 and Technical Specifications.

B. All Contractors, Subcontractors, Vendors and the like shall be required to familiarize themselves with said provisions.

1.2 SUMMARY

A. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to establish a seeded turf landscape, as indicated on the Contract Documents and includes, but is not necessarily limited to, the following:

1. Seeded lawns
2. Seeded slopes and buffers
3. Maintenance and protections

1.1 RELATED SECTIONS

A. Related sections include the following:

1. Section 015713 TEMPORARY EROSION & SEDIMENTATION CONTROLS
2. Section 329300 PLANTING; Sequencing of work
3. Section 329119 LANDSCAPE GRADING; Installation of planting soil

1.2 REFERENCES

A. The following standards shall apply to the work of this Section.

1. NTEP: National Turfgrass Evaluation Program, Beltsville Agricultural Research Center – West, Beltsville MD 20705

1.3 INFORMATION SUBMITTALS

A. In accordance with Conditions of the Contract and Division 01 Section SUBMITTALS

B. Submit proof of landscape contractor's experience to the Owner in accordance with QUALITY ASSURANCE paragraph of this Section.

1.4 ACTION SUBMITTALS

A. In accordance with Conditions of the Contract and Division 01 Section SUBMITTALS

B. At least 30 working days prior to intended use, the Contractor shall provide the following samples and submittals for approval in conformance with the requirements of Division 1 Section, SUBMITTALS. Do not order materials until Owner's Representative's approval of samples, certifications or test results has been obtained. Delivered materials shall closely match the approved samples. Acceptance shall not constitute final acceptance. The Owner reserves the right to reject on or after delivery any material that does not meet these Specifications.

1. Fertilizer:
   a. Submit product literature of seeding fertilizer and certificates showing composition and analysis.
2. Chemical Treatments:
   a. Submit product literature of pesticides proposed for use (herbicides and insecticides) and certificates showing composition, analysis and dilution and application rates.
   b. Submit Safety Data Sheets (SDS) for all proposed pesticide treatments.
   c. Maintain and submit Log of Use of chemical treatments, including:
      1) Product applied
      2) Date of application
      3) Quantity applied at each application
3. Seed: Submit a manufacturer's Certificate of Compliance to the Specifications with each shipment of seed. Include in certificates the guaranteed percentages of purity, weed content and germination of the seed, and also the net weight and date of shipment. No seed may be sown until the Contractor has submitted the certificates.
4. Erosion Control Matting (Blankets): Submit manufacturer's literature.
5. Hydroseeding: Prior to the start of hydroseeding, submit a certified statement as to the number of pounds of materials to be used per 100 gallons of water with conversion to pounds per acre application rate.
6. Wood Fiber Mulch: Submit manufacturer's literature.
7. All additives needed to amend a specific soil in order to meet these specifications.

1.5 QUALITY ASSURANCE – LANDSCAPE CONTRACTOR

A. The Landscape Contractor shall be the same firm that is installing planting and establishing turf as described in respective Division 32 Sections.

B. Qualification of Landscape Contractor: The work of this Section 32 9200 SEEDED TURF shall be performed by a landscape contracting firm which has successfully installed work of a similar quality, schedule requirement, and construction detailing with a minimum of five-years of experience. Proof of this experience shall be submitted per SUBMITTALS paragraph of this Section 32 9200 SEEDED TURF.

C. Qualification of Foreman or Crew Leader: All work of seeding shall be supervised by a foreman or crew leader who is a certified landscape professional or a certified horticulturist.

1. Landscape professional shall be a NYSNLA Certified Nursery Professional or industry related degree.
2. Pesticide Applicator: NY State Licensed, commercial.
3. Certification shall be current. Proof of certification shall be submitted per SUBMITTALS paragraph of this Section 32 9200 SEEDED TURF.

1.6 DELIVERY, STORAGE AND HANDLING

A. Mixing, applying and/or disposing of herbicides shall always be in accordance with instructions on their labels and all applicable federal, state, and local regulations. All applicators must wear the required personal protective equipment specified on the herbicide label.

B. Take precautions to avoid herbicide applications before or during rain or precipitation events. Monitor weather conditions and adjusting the work schedule as appropriate for the herbicide and application method to be used.

C. Assume responsibility for any damage to trees, shrubbery or turf beyond the target area.

D. Store liquids in tightly closed containers protected from freezing and excessive heat

E. Ensure the public does not enter the work area while herbicide application or spraying is underway.

F. Where turf is selectively removed by clearing and grubbing, discard debris generated from the work off site in a legal manner. Do not remove soil from the Project Limits unless directed to do so by the Owner.

G. Chemical Treatments: Cease operations and notify the Owner immediately if safety of adjacent structures or workers appears to be endangered. Take precautions to properly support structures and protect workers. Do not resume operations until safety is restored.

1.7 PROJECT CONDITIONS

A. Inspect areas to be prepared and seeded before starting work and any defects such as overly compacted soils or surface drainage problems and make written report of such to the Owner's Representative prior to beginning this work. The commencement of work shall indicate Landscape Contractor's acceptance of the areas to be improved, and assumption of full responsibility for the work of this Section.

B. The Contractor shall be solely responsible for judging the full extent of work requirements involved.

1.8 INTEGRATED PEST MANAGEMENT (IPM)

A. Definition: Integrated Pest Management (IPM) is a systematic approach to managing pest, which focuses on long-term prevention or suppression with minimal impact on human health, the environment and nontarget organisms. IPM incorporates all reasonable measures to prevent pest problems by properly identifying pests, monitoring population dynamics, and utilizing cultural, physical, biological or chemical pest population control methods to reduce pests to acceptable levels.

B. The Owner's Representative shall determine reasonable measures that the Contractor may use to manage pests.

C. The first step in practicing IPM on this project is to establish a dense and healthy stand of grass. Developing an IPM program is an essential aspect of this contract. Make all submittals on a timely basis. Monitor for pest problems and alert the Owner's

Representative when pest populations have been observed and chemical controls are believed to be warranted.

PART 2 - PRODUCTS

2.1 PLANTING SOIL

A. Planting soil specified under Section 32 9113 PLANTING SOIL and installed under Section 32 9119 LANDSCAPE GRADING.

2.2 SOIL ADDITIVES

A. Soil additives and amendments shall be specified under Section 32 9119 LANDSCAPE GRADING, except for additional applications of fertilizer that shall be applied under the work of this Section 32 9200 SEEDED TURF.

2.3 SEED – GENERAL

A. Seed mixture shall be fresh, clean, new crop seed. Grass shall be of the previous year's crop and in no case shall the weed seed content exceed 0.25% by weight. The seed shall be furnished and delivered in the proportion specified below in new, clean, originally unopened packages, sealed and properly labeled containers, bearing guaranteed analysis.

B. All seed shall comply with State and Federal seed laws and shall carry 'Certified State of Origin' tags on their bags or containers at the time of seeding. Seed shall conform to applicable state seed laws and standards of minimum purity, minimum germination, maximum crop seed, maximum weed seed, and be free of noxious weed seed as specified in this Section.

C. Seed germination test results for each seed type and cultivar must be performed within 10 months prior to landscape installation of seed, and must have no less than ninety percent (85%) germination rate.

D. All grass seed cultivar purity must be no less than ninety percent (95%) by weight.

E. Seed that has become wet, moldy or otherwise damaged shall not be acceptable.

F. Fescues shall contain Acromonium endophytes. Seed containing endophyte must be kept cool and dry at all times; do not stockpile in the sun.

G. Cultivars of Turf-type grasses shall conform to the specified ratings of the NTEP: National Turfgrass Evaluation Program, Beltsville Agricultural Research Center – West, Beltsville MD 20705

1. Tall Fescue shall be a cultivar with a Mean rating of 5.9 or better in accordance with Table 3. MEAN TURFGRASS QUALITY RATINGS OF TALL FESCUE CULTIRVARS GROWN AT FOUR LOCATIONS IN THE NORTHEAST REGION, 2007 – 2011 DATA, NTEP. Cultivar shall be in the top 2/3rds of ratings for Frost Tolerance Drought (Table 25) and Tolerance (Recovery – Table 30)

2. Strong Creeping Red Fescue shall be a cultivar with a quality rating of 5.9 or better for New Jersey (NJ2), New York (NY1), Pennsylvania (PA1) and Rhode Island (RI1) in accordance with the applicable tables of the 2008 National Fineleaf Fescue Test – 2009-13 data, NTEP.
3. Bluegrass shall be a cultivar with a quality rating of 5.9 or better for Illinois (IL1, IL2), Massachusetts (MA1), New Jersey (NJ1, NJ2, NJ3) in accordance with the 2011 National Kentucky Bluegrass Test – 2014 data, NTEP.
4. Ryegrass shall be a cultivar with a quality rating of 5.9 or better for Illinois (IL1), Massachusetts (MA1), New Jersey (NJ2, NJ3) Pennsylvania (PA1, PA2) in accordance with the 2010 National Perennial Ryegrass Test – 2011-14 data, NTEP.

2.4 TYPE 1 – CORNELL TURF GRASS SEED BLEND

A. This grass seed will be used without exception for all non-athletic turf campus lawn seedings unless specified otherwise in writing by the Architect.

B. This seed mix will consist of the following by weight:

1. 46% of a minimum 2 varieties of endophyte enhanced perennial rye

2. 49% of a minimum 2 varieties of improved turf type tall fescue

3. 5% of either a Midnight-type or Mid–Atlantic –type Kentucky Bluegrass.

C. All seeds shall have performed in the top statistical grouping from the most recent NTEP trials conducted for the species.

D. This blend is on file at Banfield-Baker, Lakeside Sod, Winfield and Crosman Seeds, or you may have your blend reviewed by Owner's Representative and mixed by a seed dealer of your choice.

E. Seed may NOT be mixed on site. If seed mixed by a dealer, the contractor shall furnish the owner the dealer's guaranteed statement of the composition of the mixture. A sufficient number of All seed labels for seed used on campus will be furnished to the Owner's Representative for review, and then incorporated into the owner's project files.

2.5 WOOD FIBER MULCH

A. Wood fiber mulch to cover hydro seeded areas shall be biodegradable, dyed, wood fiber mulch. It shall be non-toxic and free of plant-growth or germination inhibitors, with maximum moisture content of 12 percent and a pH range of 4.5 to 7.5.

B. Fiber mulch shall have the following characteristics:

1. It shall be dyed dark green color for easy metering and confirmation by CO.
2. It shall be formulated to allow machinery to efficiently without clogging or clumping at the nozzle.
3. When mixed with water it shall be dispersed into a uniform slurry at an accelerated rate to maintain construction schedules.
4. Capable of staying in suspension of uniform consistency for the duration of the application.

5. Full application rate shall be 2,500 pounds per acre.
6. Reduced application rate for scalped areas of existing turf: as determined by the Contractor and reviewed by the CO, the reduced application rate shall allow for new seedling protection while allowing existing grass plants to reestablish.

2.6 HYDRAULICALLY APPLIED BONDED FIBER MATRIX

A. Mulch to cover hydroseeded areas with slopes 5H:1V or steeper shall be Bonded Fiber Matrix (BFM).

B. BFM shall be a hydraulically-applied, 100% biodegradable, United States-manufactured matrix composed of 100% recycled thermally refined wood fibers and naturally derived cross-linked biopolymers. The BFM shall be phyto-sanitized, free from plastic netting, and when cured shall form an intimate bond with the soil surface to create a continuous, porous, absorbent and flexible erosion resistant blanket that allows for rapid germination and accelerated plant growth.

C. The BFM product shall have a cure time of approximately 24 to 48 hours with a manufacturer's specified application rate from 3,000 to 4,000 pounds per acre based on slope length and inclination. BFM product shall be greater than 90 percent effective at reducing erosion when subjected to a 5-inches-per hour rain event for durations of 60 minutes. It shall have Wet Bond Strength of 6 lb/ft in accordance with ASTM D6818, water-holding capacity of 1,400-percent per ASTM D7367. It shall be 100-percent biodegradable in accordance with ASTM D5338.

D. BFM product shall conform to Testing Protocols and Procedures as developed by the Erosion Control Technology Council (ECTC), www.etc.org.

E. The primary goal for selecting and using the hydraulically applied BFM product shall be erosion control during extended period of inclement weather. The additional benefit of establishing permanent turf shall also be weighed in selecting and approving the recommended product, especially in light of the schedule of site stabilization and schedule of completion.

2.7 EROSION CONTROL BLANKETS

A. Erosion control blankets shall be 100% biodegradable, woven mesh blankets designed specifically to nurture seed germination and growth and prevent water born erosion.

B. Erosion control blankets shall be BioNet by North American Green, Curlex NetFree by American Excelsior Company, or BioD-OCF by RoLanka International, Inc, or approved equal. Synthetic netting shall not be permitted.

2.8 HERBICIDES, CHEMICALS AND INSECTICIDES

A. Provide chemicals and insecticides as needed for fungus or pest control. All chemicals and insecticides shall be in accordance with authorities having jurisdiction and manufacturer's written recommendations for the intended uses and application rates.

1. White Grub Control Chemicals:
   a. Short-term curative controls: insecticides such as carbaryl and trichlorfon to control white grubs. Insecticides shall be selectively toxic to large insects

through direct application or by injections. Insecticides shall either interfere with the cholinergic nervous system of white grubs and cause death because the effects of the neurotransmitter acetylcholine cannot be terminated by caramoylated acetylcholinesterase or they shall interfere with an essential nervous system enzyme, such a cholinesterase.

b. Long-term preventative controls of white grub shall be chloranthraniliprole or approved equal chemical, that regulate the flow of calcium into the cell cytoplasm to control muscle contraction and affecting the ryanodine receptors in the insects muscle fiber, resulting in muscle paralysis leading to death.

B. Pre-emergent crabgrass control

1. Pre-emergent crabgrass control shall be Dithiopry, which alters microtubule polymerization and stability by 'interacting with microtubule associated proteins and or microtubule organizing centers.
2. Pre-emergent crabgrass control shall be Prodiamine by Syngenta or approved equal. Control chemical shall work by inhibiting mitotic processes in plants and controlling susceptible weeds by preventing growth and development of newly germinated weeds.
3. Pre-emergent crabgrass control products shall have LD50 Oral levels >3,000 mg/kg in accordance with published SDS information.

C. Herbicide to eradicate non-grass species, include post-emergent crabgrass

1. Herbicide shall be Tenacity (Mesotrione) as manufactured by Syngenta, or approved equal, to inhibit plant enzymes essential to photosynthesis and preventing formation of carotenoids in susceptible plant species, whereby light energy and by-products of photosynthesis destroy chlorophyll and cell membranes, causing bleaching of leaves, followed by necrosis and death of the plant.

2. Liquid application, using dilution and application rates per manufacturer's product literature.

2.9 FERTILIZER

A. Fertilizer shall be a commercial product complying with the State and United States fertilizer laws. Deliver to the site in the original unopened containers that shall bear the manufacturer's certificate of compliance covering analysis.

B. Nitrogen Fertilizer: Ammonium Sulfate (NH4)2SO4

1. Granular grade fertilizer
2. Fertilizer analysis for nitrogen-phosphorus-potassium (N-P-K) shall be 21-0-0.

C. Soluble liquid fertilizer for use in hydroseeding equipment: Provide a standard NPK formulation designed to provide one pound of Phosphorus per 1,000 square feet.

2.10 WATER

A. Contractor shall provide all labor and water required to establish turf. During the establishment period the Contractor shall water as required to insure that soil moisture is maintained to a sufficient depth to ensure germination and establishment. See Part 3 requirements.

1. Watering shall be done in a manner that will provide uniform coverage, prevent erosion due to application of excessive quantities over small areas, and prevent damage to the finished surface by the watering equipment. The Contractor shall furnish sufficient watering equipment to maintain required water levels in the soil.
2. Water shall not contain elements toxic to plant life.

PART 3 - EXECUTION

3.1 FILLING AND COMPACTION

A. Placement of planting soil shall be in accordance with Section 32 9119 LANDSCAPE GRADING.

B. Immediately before seeding in lawn areas, planting soil shall be restored to an even condition. All rocks greater than 2-inch diameter in the top two inches of the soil shall be removed.

3.2 TURF ESTABLISHMENT – GENERAL

A. It is an essential aspect of this Contract to establish a full and healthy turf landscape meeting the needs of the Owner, in accordance with the requirements of this Specification and as directed by the Owner's Representative.

B. Contractor shall obtain Owner's Representative's written approval of fine grading work before doing any seeding.

C. All turf areas disturbed by the Contractor that is the result of negligence of the Contractor or any of his assigned workers or sub-contractors outside the limit of seeding shall be prepared and seeded as specified herein and as directed by the Owner at no additional cost.

3.3 APPLICATION LIME OR ACIDULANTS FOR TURF AREAS

A. In accordance with the requirements of Section 32 9119 LANDSCAPE GRADING and as noted below under Article governing fertilizer application.

3.4 EXAMINATION

A. Verify limits of turf and other types of ground cover materials in the field with drawings. Verify areas where imported planting soil have been placed. Notify Owner's Representative of discrepancies prior to proceeding with lawn work.

B. Examine finish surfaces, grade, topsoil and planting soil quality, and depth.

C. Do not start lawn work until unsatisfactory conditions are corrected. Prevent excess compaction of lawn areas throughout the construction period.

3.5 GENERAL SEEDING PRINCIPLES

A. The following principles shall be applied to all seeding activities.

1. Protect all planting soils against erosion and sedimentation. Schedule seeding operations to avoid loss of planting soil.
2. The seedbed shall be weed free, clod-free, smooth, firm but not overly compacted and moist but not wet.
3. Apply seed at times of the year when weed competition is at its lowest.
4. Apply seed in a manner that provides direct seed to soil contact. Seed application system employed by the Contractor that does not apply seed directly to the surface of the soil or cultivates the seed into the soil shall be rejected.
5. Verify water sources for supplemental irrigation are available to maintain soil moisture.
6. Keep seed moist throughout the germination period.
7. Light and temperature play a key role in successful germination. Manage seeding operations to utilize light and temperature to the greatest advantage.

3.6 PREPARE SEED BED

A. Perform a pH test, sieve, and nutrient analysis of the prepared and placed planting soil and advise the results to the Owner's Representative prior to adding limestone or other soil amendments.

B. Grade lawn areas to a smooth, free draining even surface with a loose, moderately coarse texture. Roll, scarify, rake, and level as necessary to obtain true, even lawn surfaces and fill depressions as required to drain. Correct irregularities in the surface resulting from tillage operations to prevent formation of depressions or water pockets.

C. Remove debris. Remove stone 0.75-inch or larger by handpicking, fine tooth aluminum grading rakes, and/or mechanized stone picker. When topsoil has hardened, cultivate soil to a four inch depth by plowing, discing, harrowing, or otherwise scarifying and loosening the topsoil.

D. Rake area with fine toothed aluminum grading rake before placing seed to obtain a smooth surface at the proper elevation. Drag area with a wood float to level out minor humps and hollows. Beds shall have a smooth friable uniform surface, free of areas ponding water.

E. Do not move heavy objects except necessary lawn making equipment over the lawn areas after the soil is prepared unless it is again loosened and graded. Level undulations and irregularities in the surface.

F. Place starter fertilizer at the rate of 4 lbs. per 1,000 S.F. and mix into full depth of topsoil.

3.7 SEEDING

A. The season for seeding shall be from April 1 to June 1 and from August 15 to September 15. The actual planting of seed shall be done, however, only during periods within these

specified seasons that are normal for such work as determined by weather conditions, by accepted practice in this locality and as approved by the Owner. Schedule seeding operations to insure seeding and placement of erosion control blankets by October 15th.

B. To prevent loss of soil via water and wind erosion and to prevent the flow of sediment, fertilizer, and pesticides onto roadways, sidewalks, and into catch basins, seed turf areas within 5 Days of spreading and fine grading the planting soil.

C. Seed only when the bed is in a friable condition, not muddy, dry or hard.

D. Limit of grading and earthwork shall be limit of seeding unless otherwise indicated on the Contract Documents. All landscape areas disturbed outside the limit of seeding shall be prepared and seeded as specified herein at no additional cost to the Owner.

E. Means and methods of seeding shall be determined by the Contractor based on his/her experience, site conditions, season of seeding, weather conditions and any, all or other environmental conditions. Seeding of turf may be by Conventional Seeding Method, Hydroseeding, Drill Seeding or other method selected by the Contractor to insure full seed to soil contact.

F. Following application of seed apply bonded fiber matrix to the all seeded areas on slopes at rates established by the manufacturer's written instructions. Wood fiber mulch may be used on relatively flat areas within designated project limits.

1. For slopes that are steeper than five to one (5H:1V), apply a separate application of bonded fiber matrix immediately following the sowing of seed. Apply the Bonded Fiber Matrix at the manufacturer's recommended application rates.
2. Do not apply the bonded fiber matrix in advance of rainfall. Install bonded fiber matrix to ensure that it dries completely for the manufacturer's recommended minimum time period prior to rainfall. In the event of rainfall during the required drying period, reapply additional seed and bonded fiber matrix to all eroded, slumping or water affected areas as directed by the Owner's Representative.

3.8 INSTALLATION OF EROSION CONTROL BLANKETS

A. ECBs shall be installed on all areas where planting soil has been spread and seed has been sown and landform or service function of the facility suggests a greater susceptibility to erosion. This includes all slopes, walkway shoulders, swales of shallow slope, (steep swales shall be armored with crushed stone), detention basins, level spreaders and all other miscellaneous areas disturbed and restored as part of this Contract.

B. Erosion control blankets (ECBs) shall be installed on the overflow surfaces of the level spreaders of all permanent detention basins as noted under the Division 31 Section TEMPORARY EROSION AND SEDIMENTATION CONTROL. Provide minimum 10 foot width such that the blankets extend down slope either side of the level spreader sufficiently to control high water event erosion of the level spreader landform.

C. Install ECBs in accordance with manufacturer's instructions.

D. Maintenance shall consist of repairs made necessary by erosion, wind, or any other cause. Maintain, protect, repair, or replace the erosion control material until the Termination of the Plant and Warranty Period.

3.9 WATERING OF TURF AREAS

A. Establish turf.

1. Apply supplemental irrigation water to all turf areas to compensate for droughty conditions or infrequent rain events. Monitor available soil moisture to determine whether off-site water is required to supplement rainfall and meet the required turf establishment deadline.

B. Apply water to turfs areas immediately following sowing at a rate sufficient to ensure thorough, constant wetting of the soil to a depth of at least 2 inches during germination period. Thereafter, during the establishment period, apply sufficient water per week to maintain a consistent wetting of the soil to a depth of 2-inches. Monitor application rates to insure a uniform distribution of water to achieve these requirements.

C. Continue watering of the turf until final acceptance of all turf areas. As the turf approaches acceptance criteria, gradually lengthen the time period between supplemental watering events, applying water less frequently but at greater applications per watering. The goal is to deepen the wetted depth of the soil to encourage a deeper rooting system.

D. Supervise watering operation to prevent run-off. Supply all pumps, hoses, pipelines, and sprinkling equipment. Repair all areas damaged by water operations.

3.10 FERTILIZING TURF IN LAWN AREAS

A. Fertilizing: The first application of fertilizer is specified, provided, performed and paid for under Section 32 9119 LANDSCAPE GRADING. A second application of nitrogen fertilizer shall be applied to seeded areas at the time of the first mowing and shall be performed and paid for under this Section. This second application shall be applied at a rate that ensures that one-half pound of nitrogen is applied to each 1,000 square feet. A third application of nitrogen fertilizer shall be applied to seeded areas approximately two months after the second application and shall be paid for under this Section. This third application shall correspond to the following application rates dependent upon the month of application.

1. The springtime application of fertilizer shall occur during the last two weeks of March. Apply 0.5 pounds of nitrogen per 1,000 square feet.
2. The early summer application of fertilizer shall occur during the last first two weeks of June. Apply 0.5 pounds of nitrogen per 1,000 square feet.
3. The fall application of fertilizer shall occur during the last two weeks of August. Apply 0.5 pounds of nitrogen per 1,000 square feet.
4. The last application of fertilizer shall occur during the first two weeks of October. Apply 0.5 pounds of nitrogen per 1,000 square feet.

B. Dispose of all material and debris generated during the fertilizing operation. Dispose of material and debris off site in a legal manner.

C. Do not apply lime or fertilizer other than nitrogen to the turf within the Cemetery walls.

D. Fertilizer shall be applied when the grass has germinated and the turf is dry.

E. Fertilizer shall be evenly distributed. Turn the fertilizer spreader off when making sharp turns to avoid high concentrations of fertilizer.

F. Temporarily store, mix and load fertilizer on parking lot or roadway pavement areas. If fertilizer spills, sweep up fertilizer immediately and dispose of the fertilizer off site at the end of the day in a legal manner.

3.11 HERBICIDE, CHEMICAL AND INSECTICIDE APPLICATION

A. Application of fertilizer, herbicides, pesticides and fungicides shall be made by landscape professionals certified as either Registered Technicians or Commercial Applicators through the state of New York.

B. Herbicide Application: As directed by the Owner's Representative, provide sufficient applications of Tenacity at the specified application rate during the months of May and again in September as necessary to control weed species in turf areas. Applications of herbicide shall be spaced two weeks apart in months specified. Review the success of the first application of Tenacity with the Owner's Representative to determine whether additional applications are required during same and subsequent months.

C. Pre-emergent crabgrass control:

1. As directed by the Owner's Representative: when Tenacity does not fully control crabgrass, apply crabgrass pre-emergent herbicide in the spring in accordance with manufacturer's written instructions. Application rates shall be as recommended by the manufacturer.

D. Controls of White Grubs:

1. When turf shows signs of white grub damage, report damage to Owner's Representative immediately.
2. Repair damaged areas of turf by raking up the damaged grass and leveling the area with new soil and immediately seed with the approved seed mix.
3. Apply curative controls of carbaryl and trichlorfon insecticide treatment in accordance with the manufacturer's written instructions.
4. When repeated grub infestations are noted and are not responding to raking soil and reseeding and short-term controls by applications of carbaryl and trichlorfon, advise the Owner's Representative of the failure of short-term controls. As directed by Owner's Representative, apply a long-term control application of chlorantraniliprole to the entire project site on schedule recommended by the manufacturer.

3.12 TURF MAINTENANCE

A. Maintenance shall begin immediately after any area is seeded and shall continue until Final Acceptance by the Owner. Perform turf maintenance generally from the first week in April though the last week in November depending on local conditions, weather and climate.

B. Protect turf areas from drought, washout by rain events and wind erosion.

C. Maintenance shall include reseeding, mowing and trimming, watering and fertilizing as specified herein. Turf work maintenance shall also include chemical treatments as required for weed, fungus and/or pest control.

D. During the maintenance period, any decline in the condition of seeded areas shall require immediate action to identify potential problems and to undertake corrective measures.

E. Watering shall be done in a manner that will provide uniform coverage, encourage a deep rooting of grass plants, prevent erosion due to application of excessive quantities over small areas, and prevent damage to the finished surface by the watering equipment.

F. After the grass in seeded areas has germinated, reseed all areas and parts of areas that fail to show a uniform stand of grass. Reseed such areas and parts of areas repeatedly until all areas are covered with a satisfactory growth of grass with no bare spots greater than 6 square inches. Reseeding together with necessary grading, fertilizing, and trimming shall be done at the Contractor's expense.

3.13 MOWING

A. Schedule:

1. Maintain a neat and trim appearance of lawn turf. Keep lawn areas neatly trimmed at the edges. Maintain the height of the turf between 2.5 and 3.5 inches.
2. Never remove more than one-third of the height of the grass plants at any single mowing.
3. To achieve these goals:
    a. Anticipate mowing all turf areas on a weekly schedule ranging between five and ten days.
    b. The average shall be once every seven days, approximately 34 cuttings in the course of an average year.
    c. When appearance and height of grass exceeds the standards indicated above, more frequent mowings may be required at no additional cost to the Owner.
    d. Additional mowings may be required by the approach of special events or due to high grass growth rates at no additional cost to the Owner.
    e. Mowing shall occur from the first two weeks of April through the first week in November as weather permits, as required by turf growth and as directed by the Owner.

B. Schedule mowing to avoid conflict with pedestrians at employee arrival and departure times at the beginning and end of the day.

C. Collect all material and debris generated during the mowing operation that blows onto pavement. Collect on the same day as mowing. Dispose of collected material off site at the end of each workday.

D. The work of this item shall include both mowing of turf areas and trimming as described herein. The final appearance of all turf areas shall be neat and uniform. The lawn shall have smooth contours without ridges, lines, and bald/scalped areas. Clippings shall not be visible.

E. Immediately prior to beginning any mowing, remove all surface trash, litter, foreign matter and debris from the area to be mowed as indicated.

F. Mow turf areas to a mowing height of between 2.5-inches and 3.5 inches. When mowing during the summer season when water conservation is paramount, moderate the mowing height to the best advantage of turf and water conservation. Final cut of the season shall be 3.5-inches height

G. Do not remove more than one-third of the blades of the grass plants at any mowing.

H. Sharpen and balance cutting blades of mowing machines after every 40 hours of use.

I. Leave clippings in place to provide a nitrogen boost as they decompose. If, in the opinion of the Owner, excessive clippings are visible, rake clipping up and remove from the project site.

J. Do not mow during rainstorms or when turf areas are wet. If, due to scheduling problems, the turf areas are mown when wet, then collect the clippings and remove them from the project site.

K. Avoid damage to trees, shrubs and site furnishings. Damage to any site item shall be reported immediately. Trees have been staked to prevent equipment damage. When landscape equipment strike stakes, straighten the stakes to original condition. Replace stakes if broken. Replace existing and new trees damaged or destroyed by mowing and trimming.

L. Trim around buildings, walls, walks, posts, and all vertical elements, as required by Owner and the Owner's Representative to maintain a neat and trim appearance. Generally, anticipating trimming after each mowing. Trim by trimmers or other mechanical devices. Under no circumstances shall trimming cause stain or damage to buildings or site features.

M. If approved by the Owner then utilize glyphosate chemical herbicide to establish a no-grow buffer around vertical elements. Width of no-mow buffer shall not exceed 2-inches nor be too narrow to prevent accidental impact by equipment.

N. Do not trim around trees or shrubs using a string trimmer when doing so will damage the thin bark of the trees.

O. All mowing equipment shall have deflector shields in place at all times to avoid injury to staff or the public.

P. Adjust cutting patterns week to week to prevent permanent wheel rutting and irregular growth patterns of grass blades. Using a variety of mowers with different wheel bases dimensions is encouraged.

Q. Make no tight turns with mowing machines. Avoid turf degradation and wheel rutting by taking broad turns or three point turns at low speeds.

R. Trim on the same day as mowing. Clean up all debris from trimming operation on the same day as trimming.

3.14 EDGING OF LAWN AREAS

A. Schedule:

1. Turf areas adjacent to pavement, at tree pits and at shrub beds shall be edged three times during the year: during the last two weeks of April; during the last two weeks of June; and during the last week of August and the first two weeks of September.

B. Edging shall be scheduled to avoid conflict with pedestrians.

C. Remove all material and debris generated during the edging operation. Dispose of material and debris at the end of each workday, off site in a legal manner.

D. The goal of edging shall be to redefine the line between the turf and shrubs, and pavement edges. Edges shall be even, unbroken lines, smooth and true.

E. Use either hand tools or mechanical edgers to edge at shrubs, shrub beds and at pavement edges.

F. All edging cuts shall be vertical.

G. Depth of edging cut shall be minimum two inches below pavement line and to the full depth of the root zone at shrub beds.

H. After edging, pull out the grass and the grass roots.

I. Do not mix grass or grass roots into the mulch of tree rings and beds.

3.15 ACCEPTANCE STANDARDS FOR SUBSTANTIAL COMPLETION OF TURF AREAS

A. Maintain turf until standards for acceptance have been met, as determined by the Owner's Representative.

B. When, in the Contractor's opinion, standards of acceptance have been achieved, notify the Owner's Representative in writing for a formal punch list inspection. Request for inspection shall be received by the Owner at least 10 Days before anticipated date of inspection.

C. The Owner's Representative will inspect the turf areas and judge the quality of turf establishment against the following Acceptance Standards. With three days of this punch list inspection the Owner's Representative will issue an inspection report. If there are items that require additional work a Punch List will be issued and the Contractor shall fulfill the requirements of the Punch List prior to requesting a second inspection for Substantial Completion. If, during the first Punch List inspection, the Owner's Representative determines the fields meet the Acceptance Requirements then Substantial Completion may be granted by formal written approval.

D. Acceptance Standards:

1. The Owner's Representative will be the sole judge of turf acceptance.

2. Seeded areas shall have a close stand of grass with no weeds present and no bare spots greater than 6 square inches over greater than 5 percent of the overall seeded area as determined by the Owner's Representative.
3. The turf shall include a mixture of the Genus species specified as determined by the Owner's Representative.
4. Seeded areas shall be free of weed species as determined by the Owner's Representative.
5. The turf is free of winter kill, dead grass, thatch, brown spots and areas of insect and pest damage as determined by the Owner's Representative.
6. The foot system of the turf is healthy, dense and has grown to a depth 2.0 to 2.5-inches as determined by the Owner's Representative based on field sampling.

E. If the Owner's Representative finds the turf areas do not meet the acceptance standards then a deficiency report will be issued with specific Punch List items identified.

1. Where deficiencies are identified and a Punch List is issued correct deficiencies identified on the Punch List. Maintain all seeded areas until deficiencies are corrected and the site is accepted by the Owner's Representative. Responsibility for maintenance of all turf areas shall be extended until deficiencies are corrected, even if final acceptance of the entire project must be extended.
2. Turf areas to be corrected shall be prepared, reseeded and maintained in accordance with the requirements of this Section.

F. If the Owner's Representative finds the turf areas meet the acceptance standards then Final Acceptance will be granted.

3.16 FINAL ACCEPTANCE

A. Review to determine Final Acceptance of turf areas will be made by the Owner's Representative upon request by the Contractor. Provide notification of at least five working days before requested review date.

B. At the time of acceptance, the Contractor shall remove any temporary barriers used to protect turf areas.

3.17 RESTORATION AND CLEAN-UP

A. Absolutely no debris may be left on the site. Excavated material shall be removed as directed. Repair any damage to site or structures to restore them to their original condition, as directed by the Owner, at no cost to the Owner.

END OF SECTION

Section 32 92 50

SOD

PART 1 - GENERAL

1.1 GENERAL

A. Requirements set forth herein are in addition to and shall be considered as complementary to the Terms and Conditions for Construction and the balance of Divisions 00 and 01 and Technical Specifications.

B. All Contractors, Subcontractors, Vendors and the like shall be required to familiarize themselves with said provisions.

1.2 SUMMARY OF WORK

A. The work of this Section shall be performed only if the Owner accepts Alternate No. 3 in accordance with the General Requirements and Section 01 2300 ALTERNATES.

B. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to establish a sodded turf landscape, as indicated on the Contract Documents. The work of this Section shall include, but not be limited to the following establishment work:

1. Existing turf removal by sod cutters
2. New sod
3. Maintenance and protections

C. The following sections include work related to this Section:

1. Section 024113 SELECTIVE SITE DEMOLITION
2. Section 312500 SEDIMENTATION AND EROSION CONTROL
3. Section 329113 PLANTING SOIL
4. Section 329119 LANDSCAPE GRADING
5. Section 329300 PLANTING

1.3 REFERENCES

A. Not applicable.

1.4 INFORMATION SUBMITTALS

A. In accordance with Conditions of the Contract and Division 01 Section SUBMITTALS

B. Submit proof of landscape contractor's experience to the Owner in accordance with QUALITY ASSURANCE paragraph of this Section.

C. At least 30 working days prior to intended use, provide:

1. Proposed schedule, methodology and protocols for removing and stripping existing sod as indicted.

1.5 ACTION SUBMITTALS

A. In accordance with Conditions of the Contract and Division 01 Section SUBMITTALS

B. At least 30 working days prior to intended use, provide the following samples and submittals for approval in conformance with the requirements of Division 1 Section, SUBMITTALS. Do not order materials until Owner's Representative's approval of samples, certifications or test results has been obtained. Delivered materials shall closely match the approved samples. Acceptance shall not constitute final acceptance. The Owner's Representative will reject on or after delivery any material that does not meet these Specifications.

C. Fertilizer:

1. Submit product literature of turf fertilizer and certificates showing composition and analysis.

D. Chemical Treatments:

1. Submit product literature of chemicals proposed for use (herbicides, fungicides, grub controls, insect controls) and certificates showing composition, analysis and dilution and application rates.
2. Maintain and submit Log of Use of chemical treatments, including:
   a. Product applied
   b. Date of application
   c. Quantity applied at each application

E. Sod: Submit a manufacturer's Certificate of Compliance to the Specifications with each shipment of sod. Include in certificates a list of grass species and percentages of each species of grass in the sod. No sod may be placed until the Contractor has submitted the certificates.

F. Certification: submit certification that the soil on which the sod is grown is classified as loam or sandy loam. Provide soil test results that comply with the requirements of Section 329113 PLANTING SOIL.

1.6 QUALITY ASSURANCE – LANDSCAPE CONTRACTOR

A. The Landscape Contractor shall be the same firm that is installing planting soil as described in Section 329113 PLANTING SOILS.

B. Qualification of Landscape Contractor: The work of this Section 329200 Sod shall be performed by a landscape contracting firm which has successfully installed work of a similar quality, schedule requirement, and construction detailing with a minimum of five-years of experience. Proof of this experience shall be submitted per SUBMITTALS paragraph of this Section 329200.

C. Qualification of Foreman or Crew Leader: All work of seeding shall be supervised by a foreman or crew leader who is a certified landscape professional or a certified horticulturist.

D. Landscape professional shall be a New York State Certified Landscape Professional certified by the NYSNLA Certified Nursery Professional or industry related degree.

E. Horticulturist shall be a New York State Certified Horticulturist as certified by the NYSNLA Certified Nursery Professional or industry related degree.

F. Certification shall be current. Proof of certification shall be submitted per SUBMITTALS paragraph of this Section.

1.7 DELIVERY, STORAGE AND HANDLING

A. Every shipment of turfgrass sod shall be accompanied by an invoice or sales slip indicating the blended mixture of turfgrass species as approved by the Owner's Representative under the Submittal requirements of this Section. Provide percentages by weight of each sown variety with each shipment.

B. Coordinate and schedule delivery of the sod to insure sod is installed the same day it is delivered to the site. Sod that has not been installed by the end of the work day shall be removed from the site and discarded in a legal manner.

C. Upon delivery to the project site, store and stockpile sod in a manner that insures the sod does not dry out, does not become wetted and saturated by rain storms and maintains an ambient temperature of no less than 50 degrees F and no greater than 80 degrees F.

D. Mixing, applying and/or disposing of herbicides shall always be in accordance with applicators must wear the required personal protective equipment specified on the herbicide label.

E. Take precautions to avoid herbicide applications before or during rain or precipitation events. Monitor weather conditions and adjusting the work schedule as appropriate for the herbicide and application method to be used.

F. Assume responsibility for any damage to trees, shrubbery or turf beyond the target area.

G. Store liquids in tightly closed containers protected from freezing and excessive heat

H. Ensure the public does not enter the work area while herbicide application or spraying is underway.

I. Where turf is selectively removed by clearing and grubbing, discard debris generated from the work off site in a legal manner. Do not remove soil from the Project Limits unless directed to do so by the Owner's Representative.

J. Chemical Treatments: Cease operations and notify the Owner's Representative immediately if safety of adjacent structures or workers appears to be endangered. Take precautions to properly support structures and protect workers. Do not resume operations until safety is restored.

1.8 PROJECT CONDITIONS

A. Do not interfere with the use of adjacent buildings or facilities. Maintain free and safe passage to and from adjacent buildings, along public access routes through the site open to the public at the time of the work of this Section.

B. Inspect areas to be prepared and sodded before starting work and any defects such as overly compacted soils or surface drainage problems and make written report of such to the Owner's Representative prior to beginning this work. The commencement of work shall indicate Contractor's acceptance of the areas to be improved, and assumption of full responsibility for the work of this Section.

C. The Contractor shall be solely responsible for judging the full extent of work requirements involved.

1.9 ON-SITE PRECONSTRUCTION CONFERENCE

A. Before the start of any work on the site, preceding the arrival of equipment, materials or vehicles to the site, and prior to the commencement of any clearing or sod cutting within the designate lawn panels, arrange a preconstruction conference on the site with the Owner's Representative and the Contractor's Certified Arborist to identify trees and shrubs that are to be protected during sodding operations, the limits of work and general restrictions. Do no clearing or sod cutting of existing turf without a clear understanding of existing conditions to be preserved. The Contractor shall be held responsible for any and all clearing, damage or destruction to existing trees and tree root system that results from the Contractor's failure to schedule and attend the preconstruction conference on site.

PART 2 - PRODUCTS

2.1 PLANTING SOIL

A. Planting soil specified under Section 329113 PLANTING SOIL and installed under Section 32 9119 LANDSCAPE GRADING.

2.2 SOIL ADDITIVES

A. Soil additives and amendments shall be specified under Section 329119 LANDSCAPE GRADING, except for additional applications of fertilizer that shall be applied under the work of this Section 32 9250.

2.3 TURFGRASS SOD

A. Sod shall be nursery grown sod grown from the following seed mixtures and in accordance with percentages as specified:

Common Name	Proportion of Seed by Weight
Kentucky Bluegrass (At least three improved varieties to	30% maximum

be approved by the Owner's Representative.)

Strong Creeping Red Fescue or Chewings Fescue (At least two improved varieties each to be approved by the Owner's Representative)	45% minimum
Perennial Rye	25% maximum

B. Sod shall be machine cut from an established sod farm specializing in the production and harvesting of top quality, grass turf products. Sod shall be machine cut at a uniform soil thickness of 3/4-inch +/- 1/4 inch, at the time of cutting. Measurement for thickness shall exclude top growth and thatch. Individual pieces of sod shall be cut to the supplier's standard width and length. Maximum allowable deviation from standard widths and lengths shall be 5 percent. Broken pads and torn or uneven ends will not be acceptable. Sod shall be at least one year old from time of original seeding.

C. Sod shall be free of grass species other than those specified in this Section. Sod shall be free of weeds.

D. Sod shall be Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in Turfgrass Producer International's "Guideline Specifications to Turfgrass Sodding." Furnish viable, big roll sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.

E. Sod shall be harvested, delivered and installed within a period of 18 hours. Soil on sod pads shall be kept moist at all times.

F. The turf shall be of sufficient density so that no surface soil is visible when mowed to a height of 1.5 inches. At the time of sale, the turf shall contain no more than one percent undesirable grasses or clover and not more than two weeds per 50 square yards. The thickness of the soil portion of the turfgrass sod should not exceed one-half inch.

G. Sod shall have no visible signs of disease or insect stress. The turfgrass sod shall be neatly mowed and be mature enough that when grasped at one end of a small roll, it can be picked-up and handled without damage.

H. Sod delivered to the construction site which does not conform to the requirements of this Section, will be rejected by the Owner's Representative and shall be removed from the site by the Contractor at no additional cost to the Owner. Sod found to contain unacceptable levels of unspecified grass species or weed species at any time up to and including Final Acceptance will be rejected by the Owner's Representative. Contractor shall remove such sod from the site at no additional cost to the Owner. Contractor shall replace unacceptable sod with new, approved sod at no additional cost to the Owner. The Owner's Representative will be the sole judge of what constitutes acceptable or unacceptable levels of unspecified grass species or weed species.

2.4 FERTILIZER

A. Fertilizer shall be a commercial product complying with the State and United States fertilizer laws. Deliver to the site in the original unopened containers that shall bear the manufacturer's certificate of compliance covering analysis.

B. Nitrogen Fertilizer: Ammonium Sulfate (NH4)2SO4

1. Granular grade fertilizer
2. Fertilizer analysis for nitrogen-phosphorus-potassium (N-P-K) shall be 21-0-0.

C. Phosphorus shall be superphosphate or triple superphosphate.

D. Potassium shall be sulfate of potash, K_2SO_4.

E. Salt indexes per unit of nutrient for nitrogen, phosphorous, and potassium shall be less than 1.0 when compared to sodium nitrate (6.3).

2.5 WATER

A. Contractor shall schedule sodding operation to ensure that all phases of the turf establishment period are watered by the automatic irrigation system specified, installed and paid for under Division 32 Section Irrigation. Areas of sod not covered by the automatic irrigation system shall be manually watered using the quick-couplers in the irrigation system. Water for irrigation will be provided by the Owner. The contractor shall furnish all labor for watering sod lawns. If sodding operation cannot be performed after installation of the irrigation system the Contractor shall be responsible to furnish his own supply of water to the site at no additional cost to the Owner. Contractor shall be responsible to furnish adequate supplies at his own cost.

B. Irrigate in a manner that will provide uniform coverage, prevent erosion due to application of excessive quantities over small areas, and prevent damage to the finished surface by the watering equipment. Furnish sufficient watering equipment to maintain required water levels in the soil.

PART 3 - EXECUTION

3.1 INSPECTIONS

A. Walk the site with the Owner's Representative and identify all surface roots of existing trees. When removing existing sod do not damage roots of existing trees. Areas where there are surface roots shall not be cut with a sod cutter.

3.2 SOD REMOVAL AND SOD CUTTING

A. Sod cutter may be walk behind or towed. Sod cutter shall have low ground pressure tires. The work of sod cutting shall include the following:

1. Existing turf shall be dry and the underlying soil moist but not wet.
2. Before lifting sod, mow the turf as close as possible to the ground.
3. Adjust cutting mechanism to remove as little of the existing topsoil as possible.
4. Cut sod in strips and remove from the lawn panel without compaction or damage to the existing topsoil left in place.
5. Remove existing sod from the site and discard in a legal manner.

3.3 FILLING AND COMPACTION

A. Placement of planting soil shall be in accordance with Section 329119 LANDSCAPE GRADING and in accordance with the design intent of the detailed drawings.

B. Immediately before sodding in lawn areas, planting soil shall be restored to an even condition. All rocks greater than 2-inch diameter in the top 2 inches of the soil shall be removed. Planting soil shall be firm, smooth and to grades as indicated.

3.4 APPLICATION LIME OR ACIDULANTS FOR TURF AREAS

A. In accordance with the requirements of Section 329119 LANDSCAPE GRADING and as noted below under Article governing fertilizer application.

3.5 TURF ESTABLISHMENT – GENERAL

A. It is an essential aspect of this Contract to establish a full and healthy turf landscape meeting the needs of the Owner, in accordance with the requirements of this Specification and as directed by the Owner's Representative.

B. Contractor shall obtain Owner's written approval of fine grading work before doing any sodding.

C. All turf areas disturbed by the contractor that is the result of negligence of the contractor or any of his assigns outside the limit of sodding shall be prepared and sodded as specified herein and as directed by the Owner at no additional cost.

3.6 GENERAL SODDING PRINCIPLES

A. The following principles shall be applied to all sodding activities.

1. Protect all planting soils against erosion and sedimentation. Schedule sodding operations to avoid loss of planting soil.
2. The sod bed shall be weed free, clod-free, smooth, firm but not overly compacted and moist but not wet.

3.7 SODDING

A. Immediately prior to sodding operations, the loam bed shall be lightly scratched with a fine toothed harrow or hand rake to provide a slightly roughened surface to accept the sodding application.

B. The soil on which the sod is laid shall be reasonably moist and shall be watered, if necessary. The sod shall be laid smoothly, edge to edge, and where continuous or solid sodding is called for on the plans sod shall be laid with the longest dimension parallel to the contours. Sodding shall start at the base of slopes and progress upwards in continuous parallel rows. Vertical joints between sods shall be staggered. Immediately after laying, press the sod firmly into contact with the soil bed by tamping, rolling, or by other approved methods so as to eliminate all air pockets. Provide true and even surfaces, insure knitting and protect all exposed sod edges, but without displacement of the sod or deformation of the sod surface.

3.8 SOD SEASONS

A. Contractor shall schedule sodding operations to ensure full establishment of root systems into planting soil no less than 6 weeks before Final Acceptance to insure the sod root system knits into the planting soil before the sod protection fencing is removed and the lawn panels are made accessible to the public.

B. The season for sodding shall be from April 15 to June 1 and from September 15 to September 30 except as directed by the Owner's Representative to achieve the requirements of the above Paragraph A. The actual placement of sod shall be done, however, only during periods within these specified spring and fall seasons that are normal for such work as determined by weather conditions, by accepted practice in this locality and as approved by the Owner's Representative.

C. To prevent loss of soil via water and wind erosion and to prevent the flow of sediment, fertilizer, and pesticides onto roadways, sidewalks, and into catch basins, place sod within 3 Days of spreading and fine grading the planting soil.

D. Sod only when the bed is in a friable condition, not muddy or hard.

E. Means and methods of sodding shall be determined by the Contractor based on his/her experience, site conditions, season of sodding, weather conditions and any, all or other environmental conditions.

3.9 WATERING OF TURF AREAS

A. Establish turf. To that end, application of supplemental irrigation water will be required. Monitor available soil moisture to determine the rate of supplemental water required to supplement rainfall and meet the required turf establishment deadline.

B. Apply water to the turfs areas immediately following sodding at a rate sufficient to ensure thorough wetting of the soil to a depth of at least 3 inches. Supervise watering operation to prevent run-off. Supply all pumps, hoses, pipelines, and sprinkling equipment. Repair all areas damaged by water operations.

3.10 LAWN MAINTENANCE – GENERAL REQUIREMENTS

A. Maintenance of sod shall include mowing and watering, and resetting and straightening of protective barriers. Any decline in the condition of sodded areas shall require immediate action to identify potential problems and to undertake corrective measures.

B. Maintenance for Sodded Areas: Maintenance shall begin immediately after the lawn panels are sodded and shall continue until the sod is fully knit as determined by the Owner's Representative. After tent has been removed, the Contractor shall repair and restore the sodded areas with new sod meeting the requirements of this Section. Maintenance on the all sodded areas shall continue for the length of the contract duration and Final acceptance.

C. Maintenance shall include re-sodding, mowing, watering, weeding, and fertilizing a minimum of two times in addition to the fertilizer incorporated by harrowing into the spread loam, and resetting and straightening of protective barriers. Lawn work maintenance shall also include chemical treatments as required for fungus, weed and pest control.

D. During the maintenance period, any decline in the condition of sodded areas shall require immediate action to identify potential problems and to undertake corrective measures.

E. Protection

1. Sod areas shall be protected by a 3-foot high barrier constructed of 2 inch by 2 inch hardwood stakes or iron pipes set 18 inches in the ground at 10 foot intervals and connected by No. 10 wire. Flags of white cloth shall be secured to the wire at center points between stakes.
2. Barriers must be raised immediately after lawn construction and shall be maintained until Acceptance.

F. All sod shall have become established. Dead portions of sod shall be removed and replaced. All joints between sod pieces shall be filled with planting soil. All pieces of sod shall have knit to loam.

3.11 FERTILIZING

A. Fertilizing: Review fertilizer operations with Owner's Representative and the Owner prior to all fertilizer applications. The first application of fertilizer is specified, provided, performed and paid for under the Section 329119 LANDSCAPE GRADING. A second application of nitrogen fertilizer shall be applied to sodded areas approximately two months after the sod is installed. Phosphorus and potassium shall be applied proportionally in accordance with the recommendations of the soil tests and the quantities previously integrated into the soil during the first application. This second application shall correspond to the following application rates dependent upon the month of application.

1. The springtime application of fertilizer shall occur during the last two weeks of March. Apply 0.5 pounds of nitrogen per 1,000 square feet.
2. The early summer application of fertilizer shall occur during the last first two weeks of June. Apply 0.5 pounds of nitrogen per 1,000 square feet.
3. The fall application of fertilizer shall occur during the last two weeks of August. Apply 0.5 pounds of nitrogen per 1,000 square feet.
4. The last application of fertilizer shall occur during the first two weeks of October. Apply 0.5 pounds of nitrogen per 1,000 square feet.

B. Dispose of all material and debris generated during the fertilizing operation. Dispose of material and debris off site in a legal manner.

C. Fertilizer shall be applied when the turf is dry.

D. Fertilizer shall be evenly distributed. Turn the fertilizer spreader off when making sharp turns to avoid high concentrations of fertilizer.

E. Temporarily store, mix and load fertilizer on parking lot or roadway pavement areas. If fertilizer spills, sweep up fertilizer immediately and dispose of the fertilizer off site at the end of the day in a legal manner.

3.12 MOWING

A. Schedule: there shall be no minimum number of mowings. Mow and trim on the following schedule from the time of germination until final acceptance of the entire project.

B. Maintain a neat and trim appearance of lawn turf.

C. Keep lawn areas neatly trimmed at the edges. Maintain the height of the turf between 2.5 and 3.5 inches.

D. Never remove more than one-third of the height of the grass plants at any single mowing.

E. To achieve these goals:

1. Anticipate mowing all turf areas on a weekly schedule ranging between five and ten days.
2. The average shall be once every seven days, approximately 34 cuttings in the course of an average year.
3. When appearance and height of grass exceeds the standards indicated above, more frequent mowings may be required at no additional cost to the Owner.
4. Additional mowings may be required by the approach of special events or due to high grass growth rates at no additional cost to the Owner.
5. Mowing shall occur from the first two weeks of April through the first week in November as weather permits, as required by turf growth and as directed by the Owner.

F. Schedule mowing to avoid conflict with pedestrians at employee arrival and departure times at the beginning and end of the day.

G. Collect all material and debris generated during the mowing operation that blows onto pavement. Collect on the same day as mowing. Dispose of collected material off site at the end of each workday.

H. The work of this item shall include both mowing of turf areas and trimming as described herein. The final appearance of all turf areas shall be neat and uniform and fully integrated with the established adjacent turf lawns. The lawn shall have smooth contours without ridges, lines, and bald/scalped areas. Clippings shall not be visible.

I. Immediately prior to beginning any mowing, remove all surface trash, litter, foreign matter and debris from the area to be mowed as indicated.

1. Mow turf areas to a mowing height of between 2.5-inches and 3.5 inches. Final cut of the season shall be 3.5-inches height
2. Do not remove more than one-third of the blades of the grass plants at any mowing.
3. Sharpen and balance cutting blades of mowing machines after every 40 hours of use.
4. Leave clippings in place to provide a nitrogen boost as they decompose. If, in the opinion of the Owner, excessive clippings are visible, rake clipping up and remove from the project site.
5. Do not mow during rainstorms or when turf areas are wet. If, due to scheduling problems, the turf areas are mown when wet, then collect the clippings and remove them from the project site.
6. Avoid damage to trees, shrubs, site furnishings and gravestones. Damage to any site item shall be reported immediately.
7. Trim around buildings, walls, walks, posts, and all vertical elements, as required by Owner and the Owner's Representative to maintain a neat and trim appearance. Generally, anticipating trimming after each mowing. Trim by trimmers or other

mechanical devices. Under no circumstances shall trimming cause stain or damage to buildings or site features.

8. Do not trim around trees or shrubs using a string trimmer when doing so will damage the thin bark of the trees.
9. All mowing equipment shall have deflector shields in place at all times to avoid injury to staff or the public.
10. Adjust cutting patterns week to week to prevent permanent wheel rutting and irregular growth patterns of grass blades. Using a variety of mowers with different wheel bases dimensions is encouraged.
11. Make no tight turns with mowing machines. Avoid turf degradation and wheel rutting by taking broad turns or three point turns at low speeds.
12. Trim on the same day as mowing. Clean up all debris from trimming operation on the same day as trimming.

3.13 EDGING OF LAWN AREAS

A. Schedule:

1. Turf areas adjacent to curbing, walls, pavement, at tree pits and at shrub beds shall be edged three times during the year: during the last two weeks of April; during the last two weeks of June; and during the last week of August and the first two weeks of September. Perform edging within contract duration only.

B. Edging shall be scheduled to avoid conflict with pedestrians.

C. Remove all material and debris generated during the edging operation. Dispose of material and debris at the end of each workday, off site in a legal manner.

D. The goal of edging shall be to redefine the line between the turf and shrubs, and pavement edges. Edges shall be even, unbroken lines, smooth and true.

E. Use either hand tools or mechanical edgers to edge at shrubs, shrub beds and at pavement edges.

F. All edging cuts shall be vertical.

G. Depth of edging cut shall be minimum two inches below pavement line and to the full depth of the root zone at shrub beds.

H. After edging, pull out the grass and the grass roots.

I. Do not mix grass or grass roots into the mulch of tree rings and beds.

3.14 TURF ACCEPTANCE

A. Following the minimum required maintenance periods for turf construction, the Contractor shall request the Owner's Representative in writing for a formal inspection of the completed work. Request for inspection shall be received by the Owner's Representative at least 10 Days before anticipated date of inspection.

B. Acceptance Requirements

1. At the end of the maintenance period, sodded areas shall have a close stand of grass with no weeds present and no bare spots greater than 6 square inches over greater than 5 percent of the overall seeded area as determined by the Owner's Representative, who shall be the final judge of acceptance of turf. At least 90 percent of the grass established shall be permanent grass species. If turf areas are deficient, the Contractor's responsibility for maintenance of all turf areas shall be extended until deficiencies are corrected, even if final acceptance of the entire project is extended.
2. Sodded areas to be corrected shall be prepared and re-sodded in accordance with the requirements of this Section.

C. At the time of acceptance, the Contractor shall remove temporary barriers used to protect turf areas.

3.15 RESTORATION AND CLEAN-UP

A. Absolutely no debris may be left on the site. Excavated material shall be removed as directed. Repair any damage to site or structures to restore them to their original condition, as directed by the Owner's Representative, at no cost to the Owner.

END OF SECTION

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Section 32 93 00

PLANTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The General Documents, as listed on the Table of Contents, and applicable parts of GENERAL REQUIREMENTS, shall be included in and made a part of this Section.

B. Examine all Contract Documents and all other Sections of the Specifications for requirements therein affecting the work of this trade.

1.2 SUMMARY

A. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to perform all planting work and related items as indicated on the Contract Documents and as specified in this Section and includes, but is not limited to, the following:

1. Providing and placing backfill mix
2. Planting trees, shrubs, groundcovers, ornamental grasses, vines, bulbs and perennials
3. Staking, guying, and anchoring trees
4. Planting maintenance
5. One-year guarantee period for all plants
6. Root Barriers
7. The work of providing and installing plant material shall be performed by the same contractor that installs the planting soil, specified under the work of Section 329119 LANDSCAPE GRADING.

B. The work of providing and installing plant material shall be performed by the same contractor that installs the planting soil, specified under the work of Section 32 9119 LANDSCAPE GRADING.

1.3 RELATED WORK UNDER OTHER SECTIONS

A. The following items of related work are specified and included in other Sections of the Specifications:

1. Section 32 9113 PLANTING SOIL
2. Section 329119 LANDSCAPE GRADING
3. Section 32 9200 SEEDED TURF
4. Section 32 9250 SOD

1.4 REFERENCES

A. The following standards shall apply to the work of this Section.

1. Dirr: Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation and Uses, Michael Dirr et al, latest edition: standardized plant names
2. ASNS: American Standard for Nursery Stock, latest edition, published by American Nursery & Landscape Association, (ANLA): standards for growing and harvesting plant material. American National Standards Institute (ANSI):
   a. Z60.1
3. American National Standards Institute (ANSI):
4. A300 Tree Care Operations; Tree, Shrub, and Other Woody Plan Maintenance, Standard Practices, Part 1, Pruning, latest edition

1.5 SUBMITTALS

A. The following list of submittals is for the convenience of the Contractor. The listing of submittals does not absolve the Contractor of providing all submittals specified in this Paragraph or elsewhere within the body of this Section.

1. Confirmation of availability of plant material
2. List of nursery sources
3. Proof of Landscape Contractor’s experience
4. Samples and product literature for materials specified
5. Sequencing narrative & plans showing simultaneous installation of plants and planting soils
6. Plans showing proposed limits of planting soils and volumes for all lawns and plant beds
7. Any requests for variance from the requirements of this Section for schedule of planting outside of the specified planting seasons.
8. As-Build drawings showing actual, installed limits and volumes of planting soil installed.

B. At least 120 days prior to the first day of the planting season described in this Section, submit written confirmation that the plant materials shown on the PLANT LIST are available for Genus, species, variety, size, form and Fall Hazard designation. Provide list of nurseries from which the plant material will be provided.

C. Submit proof of landscape contractor's experience to the Owner’s Representative in accordance with QUALITY ASSURANCE paragraph of this Section.

D. At least 30 days prior to ordering materials, the Contractor shall submit to the Owner’s Representative samples and manufacturer's product data as specified below. No materials shall be ordered or delivered until the required submittals have been reviewed and approved by the Owner’s Representative. Delivered materials shall closely match the approved samples. Approval shall not constitute final acceptance. The Owner’s Representative reserves the right to reject, on or after delivery, any material which does not meet these Specifications, regardless of whether the plant material was approved in the nursery or by photograph. Provide the following:

1. Planting Mulch: Submit a one quart sample.
2. Antidesiccant: manufacturer's product data.
3. Mycorrhizal Fungal Inoculant: manufacturer’s product data
4. Biostimulants: manufacturer’s product data
5. Soil Additives: manufacturer’s product data

E. Planting Soil Placement Plan: Submit minimum 30-scale plans for all areas of the Contract, showing limits of planting soil beds for all plant material specified in this Section. See Section 32 9119 LANDSCAPE GRADING or the Detailed Drawings for planting soil volume requirements. Submitted plans shall show approximate limits and depths of planting soil for trees and for plant beds. Limits of beds and volumes of planting soil will be field verified by the Owner's Representative.

F. As-Built Planting Soil Placement Plan: Following the installation of plant material, submit As-Built drawings showing the extent, limits and depths of planting soil for lawns, planting beds and trees. Volumes of planting soil will be field verified by the Owner's Representative.

1.6 EXAMINATION OF CONDITIONS

A. All areas to be planted shall be inspected by the Contractor before starting work and any defects such as subgrade elevations that will require additional excavation to insure adequate volumes of planting soil, incorrect grading or inadequate drainage shall be reported to the Owner's Representative prior to beginning this work.

B. The Contractor shall be solely responsible for judging the full extent of work requirements involved, including but not limited to providing planting soil to the depths and volumes specified, the potential need for storing and maintaining plants temporarily and/or re-handling plants prior to final installation.

1.7 QUALITY ASSURANCE

A. Qualification of Landscape Contractor: The work of this Section shall be performed by a landscape contracting firm which has successfully installed work of a similar quality, schedule requirement, and construction detailing with a minimum of five years' experience. Proof of this experience shall be submitted per SUBMITTALS paragraph of this Section.

B. Certified Landscape Professional or Certified Horticulturist shall be on the project site throughout the day-to-day performance of the work described in this Section.

C. Qualification of Arborist: an arborist certified by the New York State Arborist Association or the International Society of Arboriculture shall perform all work of pruning.

D. All plants are the full responsibility of the Contractor between the time of digging at the nursery and final acceptance. As a basis of this Contract, the Contractor will be assigned full responsibility for any decline or damage to the plant material from the time the plants are dug until the plants have gone through their one year guarantee period.

PART 2 - PRODUCTS

2.1 PLANTING SOILS

A. Planting soils shall be as specified under the work of the Section 32 9113 PLANTING SOIL of this Specification, spread and paid for under the work of Section 32 9119 LANDSCAPE GRADING as specified under the work of this Section 32 9300 PLANTING.

2.2 GRADES AND STANDARDS OF PLANTS - GENERAL

A. The Contractor shall furnish all plants shown on the Contract Documents, as specified, and in quantities listed on the PLANT LIST. No substitutions will be permitted, without written approval by the Owner's Representative. All plants shall be nursery grown unless specifically authorized to be collected as noted on the PLANT LIST.

B. Plants shall be true to the species and variety specified and shall be nursery grown in accordance with good horticultural practices. Unless approved by the Owner's Representative, plants shall have been grown at a latitude not more than 200 miles (325 km) north or south of the latitude of the project unless the provenance of the plant can be documented to be compatible with the latitude and cold hardiness zone of the planting location.

C. If proof is submitted in writing that a plant specified is not obtainable, consideration will be given to the nearest available size or similar variety, with a corresponding adjustment of the contract price.

D. Plants shall be dug during the most recent favorable harvest season and subject to the review of the Owner's Representative.

E. Plants shall be in accordance ASNS except as noted in this Section. Botanical plant names shall be in accordance with plant designations in Dirr's Manual of Woody Plants.

F. Plants shall conform to the measurements specified on the PLANT LIST, except that plants larger than those specified may be used if approved by the Owner's Representative. When so approved, larger plants shall be provided and installed at no additional cost to the Owner. Root balls of larger plans shall be increased in proportion to the size of the plant.

G. Trees and shrubs shall be specimen quality in accordance with requirements of ASNS, and shall have exceptionally heavy branching, be symmetrical, and so trained or favored in development and appearance as to be unquestionably superior in form, shape and compactness.

H. Plants shall show no signs of frost or winter damage to the foliage. Foliage shall not be in a state of drought stress. Leaves or needles shall show no signs of wilt or desiccation due to weather stress at any season of the year.

I. Plants shall be free of disease and insects, eggs, or larvae. They shall be free from physical damage, sun-scald, frost cracks, injuries and abrasions of the bark, broken branches, damaged leaders, included bark, v-shaped crotches, or other conditions that would prevent, long-term, vigorous growth and aesthetic appeal as determined by the Owner's Representative.

J. If, at any time during the performance of the Contract, any plant shows signs of graft incompatibility, as determined by the Owner's Representative, then the tree or shrub and all other similarly grafted plants of the same Genus/Species/Variety shall be rejected and removed from the site.

2.3 PLANT MATERIAL STANDARDS

A. All deciduous and evergreen trees shall meet the following standards:

1. Main leader and branches:

a. Unless otherwise designated as multi-stemmed on the PLANT LIST, trees shall have single, strong, straight central leaders, well-formed and sturdy, with no lateral branches greater than 2/3 the caliper of the main leader.
b. Branches shall not have included bark at their unions with the main
c. Branching of all deciduous trees shall be best quality representatives of the species, cultivar or variety. Trees shall have branches equally spaced around the central leader at least 6-inches apart.
d. Branches shall occupy their own space and not cross, intertwine or touch.
e. All branches on deciduous trees shall meet the trunk at angles no less than 30 degrees and no greater than 90 degrees from the vertical.

2. Foliage:
   a. All trees shall have healthy, vigorous leaves or needles of normal size, color, shape, and texture for the particular species and variety.
   b. Terminal and top whorl buds of all evergreen trees shall be in healthy and whole condition at the time of harvest.
   c. Deciduous shade trees and deciduous flowering trees shall have fall color typical for their species and variety.
3. Pruning Scars:
   a. All pruning wounds shall show vigorous bark on all edges at the time of harvest.
   b. Pruning scars within the crown of any tree shall be clean cut and shall leave no protrusion beyond the branch collar.
   c. No tree shall be pruned after the Owner's Representative has tagged the plant in the nursery except as directed by the Owner's Representative.
4. Size:
   a. Unless otherwise indicated on the PLANT LIST, the height and spread of deciduous shade trees shall be the minimum requirements.
   b. Take caliper measurements for deciduous trees 6 inches above ground level up to and including 4 inches caliper size and 12 inches above ground for larger sizes.
   c. Unless otherwise noted on the PLANT LIST, shade trees for use in or immediately adjacent to paved areas shall have no branches lower than 6.5 feet from finish grade and no higher than 7.5 feet from finish grade.
   d. Flowering trees for use in areas away from pedestrian traffic shall have the first branch of their crowns no higher than 4 feet from finish grade
   e. The height of the evergreen trees (measured from the trunk flair at the natural ground line of the tree to the midpoint of the terminal leader) shall be not less than the minimum size designated on the PLANT LIST.
5. When proposed for planting in rows, trees shall be matched in form, height and shape.
6. Nursery Culture:
   a. Collected from the Wild: Trees collected from native stands will not be accepted unless so specified on the PLANT LIST.
   b. Trees collected from wild or native stands may be considered nursery grown when they have been successfully reestablished in the nursery row and grown under regular nursery cultural practices for a minimum of two growing seasons and have attained adequate root and top growth to indicate full recovery from transplanting into the nursery row.

B. Shrubs shall meet the following standards:

1. Deciduous shrubbery shall be in accordance with the requirements of ASNS for all shrub Types for size, spread and height requirements, habit and root ball sizes and minimum number of canes unless designated otherwise on the PLANT LIST.

2. Coniferous shrubbery and broadleaf evergreen shrubbery shall be in accordance with the requirements of ASNS for all Types for size, spread and height requirements, habit and root ball sizes unless designated otherwise on the PLANT LIST.
3. Coniferous and broadleaf evergreen shrubbery shall have Shearing Designation of Natural in accordance with ASNS standards unless designated otherwise on the PLANT LIST.
4. All shrubs shall be healthy and vigorous plants which are very well shaped and symmetrical, heavily branched and budded, densely foliated, and true to form for their variety.
5. Blemishes, scars and irregularities:
    a. Scars shall be free of rot and not exceed 1/4 the diameter of the wood beneath in greatest dimension unless completely healed (except pruning scars).
    b. Pruning scars shall be clean cut and shall leave little or no protrusion from the trunk or branch.
    c. Graft unions shall be completely healed.
    d. No suckers or water sprouts.
    e. Contain no dead wood.
    f. Free of cracks, splits, or cambium peeling.
6. Collected from the Wild:
    a. Shrubs collected from native stands or established plantings will not be accepted unless so specified on the PLANT LIST.
    b. The spread of roots, bare root collected, shall be one-third greater than the spread of roots of nursery grown shrubs for the same size plant.

C. Herbaceous Perennials, Ornamental Grasses, Groundcovers:

1. In accordance with the requirements of ASNS and as follows.
2. Plants shall be container grown unless otherwise designed on the PLANT LISTS.
3. Plants shall have deeply colored foliage exceptional for their species and variety. They shall be of dense, full and compact growth, showing exceptional vigor and health in the pot or container.
4. If so designated on the PLANT LIST then plants may be grown in flats or cell-packs, from which they shall be readily removed without damage to stem and runner.
5. All container grown plants shall have a well-established root system reaching the sides of the container to maintain a firm root ball, but shall not have excessive root growth encircling the inside of the container.
6. Plants shall be healthy, vigorous and well cared for.

D. Bulbs, corms and tubers shall be in accordance with ASNS and the following:

1. Sizes shall be of largest designation common to the nursery industry, including designations such as Jumbo, Extra Large, Giant, Top, Number 1, Top forcing, largest circumference; Double Nose 1 (DN I), RD I Top.

E. Vines: as noted above for Groundcover for foliage and root system and the following:

1. Vines shall be in accordance with the ASNS Standards 2014 edition, Article 13.6.
    a. Stake length shall be minimum 4-feet with the longest trail of the vine reaching the end of the stake.
    b. Container size shall be minimum #3 container in accordance with Article 1.1.3.1 Table 1 of the ASNS Standards

2.4 ROOT SYSTEMS FOR ALL PLANTS

A. Requirements:

1. Each plant shall have an extensive, symmetrically balanced fibrous root system. Root balls shall encompass the fibrous and root feeding system necessary for the healthy recovery of the plant.
2. Any root ball that shows signs of asymmetry, girdling, injury, or damage to the root system will be rejected.
3. All parts of the fibrous root system of all plants shall be moist and fresh.
4. The root systems of all plants shall be free of disease, insect pests, eggs, or larvae.

B. Balled and Burlapped Root Balls:

1. Root ball diameters for field grown stock shall be in accordance with the diameter and depth requirements in ASNS and as follows. Field grown stock may be dug by hand or by digging machines.
2. For those plants having a coarse or wide-spreading root system because of natural habit of growth, soil condition, infrequent transplanting practice, or plants that are moved out of season, root balls of field grown stock shall be larger than the ASNS recommended sizes.
3. Conversely, if the nursery grower can demonstrate to the satisfaction of the Owner's Representative nursery cultural practices that increase root density of a tree or shrub, smaller root ball sizes may be accepted.
4. All balled and burlapped trees and shrubs shall be moved with the root systems as solid units with balls of earth firmly wrapped with untreated 8 ounce natural, biodegradable fabric burlap, firmly laced with stout, natural biodegradable cord or twine.
5. The base of the deciduous tree trunks shall be wrapped with a protective burlap layer, surrounded by a cardboard trunk protector extending no less than 36 inches upward from the root flare, and loosely tied with twine.

C. Container Grown Plants:

1. All container-grown nursery stock shall be healthy, vigorous, well rooted, and established in the container in which it is growing. Container grown nursery stock shall have a well-established root system reaching the sides of the container to maintain a firm ball when the container is removed, but shall not have excessive root growth encircling the inside of the container.
2. Containers shall be the appropriate size for the plants growing in them, in accordance with ASNS standards for Type of plant.
3. Curling or spiraling of the roots along the walls of rigid containers will not be accepted. Curling, spiraling or girdling roots within balled and burlapped material will not be accepted. Specially designed containers or chemically treated containers intended to retard circling roots are acceptable.
4. The container shall be sufficient rigid to hold the ball shape and to protect the root mass during shipment.
5. No plants shall be loose in the container.
6. When container grown and the plant is removed from the container, the visible root mass shall be healthy with white root tips.
7. Container grown plants that have roots growing out of the container will be rejected.

2.5 INOCULANTS AND STIMULANTS

A. Mycorrhizal fungal inoculant shall be live spores packaged in plastic packets. At a minimum each packet of inoculant shall contain the following:

1. Live spores of VA Endomycorrhizal fungi: Vesicular-Arbuscular mycorrihizae fungi, minimum of 8 species.
2. Live spores of Ectomycorrhizal fungi: including Pisolithus tinctorius.
3. Mycorrhizal fungal inoculant shall be manufactured by Plant Health Care Incorporated, 440 William Pitt Way, Pittsburgh, PA 15238, telephone: (800) 421-9051; Horticultural Alliance, 2946 Louise Street, Sarasota, FL 34237, (800) 628-6373; BioPlex Organics, 2213 Huber Drive, Manheim, PA 17545 (800) 441-3573, or approved equal.

B. Biostimulant

1. Biostimulant shall be a dry water soluble plant treatment that includes beneficial rhizosphere bacteria (Bacillus licheniformis, Bacillus megaterium, Bacillus polymyxa, Bacillus subtilis, Bacillus thuringiensis, Paenibacillus azotofixans), humic acids, microbial nutrients (maltodextrin, seaweed and yeast extracts) and inert ingredients.
2. Biostimulant shall be Diehard Transplant as manufactured by Horticultural Alliance, Sarasota Florida: www.horticulturalalliance.com; Soil Support Root Enhancer/Soil Amendment as manufactured by ENP Investments, LLC, Mendota IL www.enpturf.com; Tree Saver Transplant by Plant Health Care, Pittsburg PA www.planthealthcar.com , or approved equal.

2.6 STAKING, GUYING, AND ANCHORING MATERIALS

A. Stakes for supporting trees shall be of sound wood of uniform shape and size, reasonably free of knots, insects and fungi and capable of standing in the ground at least 2 years. Unless noted otherwise, stakes shall be 2-inch diameter 8-foot long round poles or approved equivalent diameter. Stakes shall be pointed at one end and stained dark green.

1. Guying system shall be lock-stitch, polypropylene webbing. It shall be low-stretch product with a tensile strength of no less than 3000 lbs, which establishes contact with the trunk of the tree with a broad, smooth surface between 0.5 and 0.75 inches wide. Webbing shall be green color. Submit guying system to the Owner’s Representative for review and approval.

2.7 MULCH

A. Bark Mulch: Mulch shall be high quality premium pine, hemlock or spruce bark mulch. Mulch shall have been aged for a minimum of six months and not longer than two years. Bark mulch shall be shredded to a uniform size; free of dirt, debris and foreign matter; with pieces no thicker than 1/4 inch. Mulch must be free of stringy material or chunks over 3 inches in size and shall not contain, in the judgment of the Owner’s Representative, an excess of fine particles. Submit sample for the Owner’s Representative's approval.

2.8 WRAPPING MATERIAL

A. Wrapping material shall be first quality, 4 inch wide heavy waterproof crepe paper manufactured for this purpose. Tape for securing wrapping material shall be a durable, weatherproof tape of same color as wrapping material.

2.9 WATER

A. Contractor shall provide all labor and water required to establish plants at no extra cost to the Owner. If possible, the Owner may furnish the Contractor upon request with an adequate source and supply of water. Contractor shall reimburse the Owner as required by the Owner. However, if the Owner's water supply is not available or not functioning, the Contractor shall be responsible to furnish adequate supplies at his own cost. All work injured or damaged due to the lack of water, or the use of too much water, shall be the Contractor's responsibility to correct. Water shall be free from impurities injurious to vegetation.

B. During the maintenance period the Contractor shall water as required to insure that soil moisture is maintained to a depth of six inches or greater at all times.

C. Watering shall be done in a manner that will provide uniform coverage, prevent erosion due to application of excessive quantities over small areas, and prevent damage to the finished surface by the watering equipment. The Contractor shall furnish sufficient watering equipment to maintain required water levels in the soil.

2.10 ANTIDESICCANTS

A. Antidesiccants shall be emulsions or other materials which will provide a protective film over plant surfaces permeable enough to permit transpiration and specifically manufactured for that purpose. Manufacturer of antidesiccant shall be subject to the Owner's Representative's approval and shall be used only after approval by the Owner's Representative. Antidesiccant shall be delivered in containers of the manufacturer and shall be mixed and applied according to the manufacturer's instructions.

PART 3 - EXECUTION

3.1 PRELIMINARY

A. Planting Soil is specified under the work of Section 329113 PLANTING SOILS and installed under the work of Section 329119 LANDSCAPE GRADING.

B. Providing ample, free-draining, pH corrected, mineral soils with good organic amendments is essential to insuring the long-term health of Plant Material.

C. Earthwork activities related to maintaining or restoring overly compacted subgrade and subsoil material to a free-draining condition are specified in Division 31 Sections. Report any subgrade or subsoil condition suspected to being overly compacted to the Owner's Representative immediately upon discovery.

D. Topsoil/Planting Soil volumes: Coordinate installation with the requirements of Section 329119 LANDSCAPE GRADING.

1. Shade trees and tall evergreen trees– provide a minimum of 1,200 cubic feet of planting soil per tree.
2. Flowering trees and tall evergreen shrubs as indicated – provide a minimum of 800 cubic feet of planting soil per plant.
3. Plant beds: minimum depth of 18-inches, continuous for the entire extent of the plant beds and standard 24-inches beyond shrub plantings at all perimeters.

4. Lawn areas, minimum depth of 9-inches. Coordinate with the requirements of Section 329200 Seeded Turf (329250 Sod).

E. Turf areas – as indicated and as specified in Section 329119 LANDSCAPE GRADING

F. Depths and volumes of planting soils for plant material specified in this Section shall be recorded with As-Built drawings. See the Submittals paragraph of this Section.

3.2 PLANT MATERIAL INSPECTIONS

A. At least one month prior to the expected planting date, the Contractor shall request that the Owner's Representative provide a representative to select and tag stock to be planted under this Section. The Contractor shall pay for the transportation, subsistence and overnight accommodations, if necessary, for the Owner's Representative's representative during the period of time required to select and tag the plant material.

B. By accepting the work of this Contract, the Contractor certifies the availability of top-quality plants in specified sizes for planting during the specified planting seasons. Further, the Contractor certifies he/she has verified specified plants are available from his/her sources of supply. Any follow-up plant tagging trips that are required due to the lack of availability of plant species, variety, and size or as a result of planting outside of the specified planting seasons, will be paid for by the Contractor. The Contractor shall be liable to reimburse the Owner for all costs of the Landscape Architect's hourly services, per diem expenses, costs of travel and any and all miscellaneous expenses that are incurred during follow-up or unproductive inspection trips.

C. All trees for the project shall be individually tagged for approval with the Owner's Representative's seals, and no trees shall be accepted for delivery to the site without such seals. Representative samples only of shrubs and ground cover plants may be tagged or marked for approval as an "Approved Typical Sample" and shipped to the site. Any shrub or groundcover plant that arrives at the construction site that does not meet the Approved Typical Sample will be rejected by the Owner's Representative and replaced at no additional costs to the Owner. Delays resulting from this rejection and replacement shall in no way relieve the Contractor of his contractual responsibility to complete the work of this Project on time.

D. Inspection and approval of plants at the source shall not impair the right of subsequent inspection and rejection upon delivery to the site, or during the progress of the work if the Owner's Representative finds that plants do not meet the requirements of the PLANT LIST or this Contract, have declined noticeably due to handling abuse, lack of maintenance, or other causes. Cost of replacements, as required, shall be borne by the Contractor.

3.3 TRANSPORTATION AND STORAGE OF PLANT MATERIAL

A. Branches shall be tied with rope or twine only, and in such a manner that no damage will occur to the bark or branches.

B. During transportation of plant material, the contractor shall exercise care to prevent injury and drying out of the trees. Should the roots be dried out, large branches broken, balls of earth broken or loosened, or areas of bark torn, the Owner's Representative may reject the injured tree(s) and order them replaced at no additional cost to the Owner. All loads

of plants shall be covered at all times with tarpaulin or canvas. Loads that are not protected will be rejected.

C. Notify the Owner's Representative three working days prior to the proposed arrival of plant material on the site. Plants must be protected at all times from sun or drying winds. Those that cannot be planted immediately on delivery shall be kept in the shade, well protected with soil, wet mulch, or other acceptable material, and kept well watered. Plants shall not remain unplanted any longer than 3 days after delivery. Plants shall be free of damage to barks, stems, branches, twigs, leaves and needles following planting operations.

3.4 PLANTING SEASONS

A. Locate all plant material sources and ensure that plants are shipped in timely fashion for installation within the following Seasons for Planting:

1. Spring: Deciduous materials - March 21 through May 1; Evergreen materials - April 15 through June 1.
2. Fall: Deciduous materials - October 1 through December 1; Evergreen materials - August 15 through October 15.

B. Do no work when the ground is frozen, snow covered, too wet or in an otherwise unsuitable condition for planting. Special conditions may exist that warrants a variance in the specified planting dates or conditions. Submit a written request to the Owner's Representative stating the special conditions and proposal variance.

C. When schedule of construction requires installation of plant material outside of these specified planting seasons, the Contractor shall bare full responsibility for planting out of season and shall be held fully responsible for any plant material losses resulting from planting out of the specified seasons. Contractor shall replace all plant material that does not meet the requirements of this Section with new plant material that conforms to the requirements of this Section.

3.5 EXCAVATION FOR PLANTING

A. In the event that rock or underground construction work or obstructions are encountered in any plant pit or bed excavation work, notify the Owner's Representative immediately. The Owner's Representative will select alternate locations. Relocation of plant pits or beds shall be provided at no additional cost to the Owner. Provide the Owner's Representative with no less than 48 hours' notice of obstruction so that a site visit can be scheduled to establish new locations for plants.

B. Installing the specified volumes of planting soil for trees and planting beds is an essential aspect of the Work of the Contract and the work of Section 32 9119 LANDSCAPE PLANTING and this Section 32 9300 PLANTING. In accordance with the requirements of the SUBMITTALS paragraph of this Section, submit the Planting Soil Placement Plan showing the limits of different beds and soil volumes. Do no work until the Owner's Representative has reviewed and accepted the planting soil placement plan.

C. Prior to excavating for plant pits and bed, verify the location of any underground utilities. Repair all damage to utility lines that is the result of negligence of the contractor or any of his assigns at no additional cost to the Owner.

D. Where lawns have been established prior to planting operation, cover the surrounding turfgrass before excavations are made in a manner that will protect turfgrass areas. Protect existing trees, shrubbery, and beds that are to be preserved in a manner that will effectively protect them during the project construction.

E. Remove rocks and other underground obstructions to a depth necessary to permit proper planting according to plans and specifications. Where underground utilities, construction, or solid rock ledges are encountered, notify the Owner's Representative immediately so that alternative locations for plantings can be made.

F. Trees shall be planted in beds with the minimum soil volumes shown on the approved Submittals. Within tree beds, the Contractor will not be required to excavate circular plant pits. Shrub pits and beds shall be excavated as noted below.

1. All tree pits dug with a machine shall have the sides of the holes scraped with hand shovels to prevent glazing or compaction of the sides of the hole. Remove and stockpile excavated planting soil for reuse as backfill for plant pit. All subsoil excavated from the bottoms of planting pits shall be removed from the site.
2. Tree and shrub pits shall be dug to encourage the root growth out of the rootball and into the surrounding planting bed.
3. Plant beds for shrub massing shall be one large and continuous excavated bed. Extend bed no less than 3 feet beyond limits of shrub root balls on perimeter of bed.
4. Plant pits and beds for shrubs shall be dug to the depth of the rootball to be planted.
5. Remove all soil from around the root flare of the stem of the plant and from the top of the rootball to determine the true depth of the rootball. All plants that have been planted and have root flares that are buried will be rejected.

G. Perennial and Groundcover Beds:

1. Beds shall be dug to a continuous depth of one foot below final grade, or as shown on the Contract Documents. Place sufficient planting soil mix to provide one foot deep beds. Remove perennials from their pots immediately before planting. Handle plants carefully to prevent damaging roots. Place each plant in individual hole and firm the planting mix around the roots. Water thoroughly and mulch as shown on the Contract Documents.
2. Where ground cover and planting beds occur in existing turfgrass areas, remove turfgrass to a depth that will ensure the removal of the entire root system, with additional bed preparation as specified in the next paragraph.

3.6 PLANTING OPERATIONS

A. Immediately following the installation of planting soil, as specified in Section 329119 LANDSCAPE GRADING, install plant material to the following requirements.

B. In the event that rock or underground construction work or obstructions are encountered in any plant pit or bed excavation work, notify the Owner's Representative immediately. The Owner's Representative will select alternate locations. Relocation of plant pits or beds shall be provided at no additional cost to the Owner. Provide the Owner's Representative with no less than 48-hours' notice of obstruction so that a site visit can be scheduled to establish new locations for plants.

C. Requirements:

1. Plants shall be installed so that the root flare is exposed. Prior to placing each plant, remove burlap from the top of the root ball and remove soil from over and around the root flare. Replace burlap.
2. Planting hole shall be at same depth as the height from the bottom of the rootball to the root flare. In certain cases it may be necessary to compensate for soil settlement, the Contractor shall set root ball slightly higher as directed by Owner's Representative.
3. Plants must be set plumb and braced in position until soil has been placed around the root ball and roots. The trunk of the tree shall not be used as a lever in positioning or moving the tree in the planting hole. The Contractor shall take care not to crack or loosen the ball during planting.
4. For balled and burlapped plants, after the plant has been set, remove ropes, strings and burlap from the top surface of the root ball. Remove at least the top half of the wire basket before backfilling. The Contractor shall not fold back burlap. Cut away burlap and discard all debris off site.
5. Mychorrhiza and biostimulants shall be added to the planting soil back fill mix after the plant has been placed in its hole. Thoroughly mix mychorrhiza and biostimulants into the upper 10 inches of backfill soil. Apply in accordance with the manufacturers written instructions and the size of the plants being installed.
6. Backfill with specified soil in 6-inch lifts to avoid injury to roots and to fill all voids. Firmly tamp by hand each lift to prevent settlement. Do not ram soil into place with feet, shovel handles or any device other than hands.
7. Mulch and thoroughly water all plants immediately after planting. Open ended hoses are not permitted. Hoses must be fitted with watering wand. Eliminate air pockets and compact the soil by flooding the tree pit or plant bed as the work progresses. Avoid walking on previously placed planting soil. After water has drained from the planting pit or bed and planting backfill has dried sufficiently, spread additional planting soil in pit or bed to bring the finished surface of the planting pit or bed to grades shown on the Contract Documents.
8. Herbaceous Perennials, Ornamental Grasses, Groundcovers and Vines:
   a. Remove plants from their containers immediately before planting. Handle plants carefully to prevent damaging roots. Place each plant in individual hole and firm the planting mix around the roots.
9. Bulbs shall be planted at depths as recommended by bulb supplier, as shown on the Contract Documents, or both.
10. Fertilizer shall be spread over the plant bed. Till the fertilizer into the planting soil at the same time as tilling approved compost into the top surface of the planting soil.
11. Spread approved compost in plant beds and tree pits to a depth of 2-inches and till the planting soil to a depth of 6-inches to integrate compost into the top layer of the planting soil
12. Do not place mulch until tilling of the fertilizer and compost has been verified by the Owner's Representative. Fertilizer application rates shall be as determined by soil testing, analysis, and testing laboratory recommendations specified, performed and paid for under Section 32 9113 PLANTING SOILS of this Specification
13. Any excess soil, debris, or trimmings shall be removed from the Project site immediately upon completion of each planting operation.

3.7 POST-PLANTING OPERATIONS

A. The Contractor shall inspect beds 24 hours after initial watering to confirm that they are draining properly. If surface water or excessively saturated plant pit soils exist, the Contractor shall immediately notify the Owner's Representative. The Owner's

Representative will direct the Contractor to perform remedial measures based upon site conditions and as specified in this Section.

B. Keeping Trees Plumb:

1. Contractor shall keep trees plumb and upright at all times.
2. Perform staking and guying at the time of planting. Stakes shall be of even height and neat in appearance and they shall not injure plant balls. Elastic webbing, belting or tape shall be installed in accordance with manufacturer's instructions. Install staking in accordance with the Detailed Drawings.

C. Pruning:

1. As directed by the Owner's Representative, each plant shall be pruned in accordance with the workmanship requirements of ANSI A300, to preserve the natural character of the plant.

D. Antidesiccant shall be applied to all evergreen and broadleaf evergreen plants in December and again in February, according to manufacturer's application recommendations and as directed by the Owner's Representative.

E. Protect lawns from damage. Any damage resulting from planting operations shall be repaired immediately at no cost to the Owner. Repair work shall be as specified and installed under the work of Division 2 Section, LAWNS, of this Specification and paid for under this Section.

F. Absolutely no debris may be left on the site. Repair any damage to site as directed by the Owner's Representative, at no additional cost.

3.8 MAINTENANCE

A. Maintenance shall begin immediately after each plant is planted and shall continue until Final Acceptance.

B. Maintenance shall consist of keeping the plants in a healthy growing condition and shall include but is not limited to watering, weeding, cultivating, pruning, re-mulching, tightening and repairing of guys, straightening of trees to a plumb position, removal of dead material, resetting plants to proper grades or upright position, maintaining the planting saucer and replacement of plants that are in decline or die.

1. Plants shall be inspected for watering needs at least twice each week and watered to promote plant growth and vitality. Do not compact planting soil in the process of water plant material. Place wood board ballast to walk between plants.
2. For trees in lawn or mulched beds, apply water to the ground surface directly under the canopy. Water shall be applied at a sufficiently slow rate to prevent run off from the soil surface.
3. Stakes shall be kept neat in appearance. Guys shall be tightened and repaired weekly as required to meet the requirements of this Section.
4. Planting beds and individual plant pits shall be kept free of weeds, and mulch shall be replaced as required to maintain the specified layer of mulch. Beds and individual pits shall be neat in appearance and maintained to the designed layout.

5. Plants that are in decline or die during the maintenance period shall be removed and replaced by the Contractor within one week of notification and replaced during that growing season, unless directed otherwise by the Owner's Representative.
6. Spraying of insecticides or herbicides shall be done by State-licensed professionals. Spraying for insects, pests and diseases shall conform to the National Arborist Association Standards under the section entitled "Standards for Pesticide Application Operations", as currently adopted and as approved by the Owner's Representative.
7. Work of pruning, fertilizing, spraying, and similar activities shall be undertaken only by Certified Arborists and licensed chemical applicators, as pertinent to the work being performed.

C. During the maintenance period, any decline in the condition of plantings shall require the Contractor to take immediate action to identify potential problems and undertake corrective measures. If required, the Contractor shall engage professional arborists and/or horticulturalists to inspect plant materials and to identify problems and recommend corrective procedures. The Owner's Representative shall be immediately advised of such actions. Inspection and recommendation reports shall be submitted to the Owner's Representative.

3.9 SUBSTANTIAL COMPLETION

A. Upon completion of all planting work, the Contractor shall request in writing that the Owner's Representative formally inspect the planting work for Substantial Completion.

B. Standards for Substantial Completion: If plant material is reviewed when it is in full leaf, leaves shall be plump with water with a shape indicative of the species and shall be free of insect, pest and disease damage. Twigs shall have living cambium for their full length. Twigs and branches shall have a full bud set for their full length, including terminal buds. Trunks and branches shall be free of frost cracks; sun scald; damage due to insects, pests, and disease; structural defects; and damage resulting from machinery or tools. Plant material inspected and reviewed when the plants are not in full leaf shall have twigs, branches and trunks meeting the above requirements. All plants regardless of the season of review shall have a minimum of 85 percent healthy, balanced branching structure with a healthy terminal leader(s) with viable terminal bud(s).

C. If any number of plants do not meet these Acceptance Standards at the time of inspection, or if in the Owner's Representative's opinion, workmanship is unacceptable, written notice will be given by the Owner's Representative to the Contractor in the form of a Punch List, which itemizes necessary planting replacements and/or other deficiencies to be remedied. The Contractor's responsibility for maintenance of all plants shall be extended until replacements are made or other deficiencies are corrected. All plants that do not meet these Acceptance Standards shall be removed from the project within 7 days of receipt of the punch list. Replacements shall conform in all respects to the Specifications for new plants and shall be planted in the same manner.

3.10 FINAL ACCEPTANCE

A. Following the correction of all Punch List deficiencies, the Contractor shall request in writing that the Owner's Representative again formally inspect the planting work. If plant materials and workmanship are acceptable, the Owner's Representative will issue a written Certificate of Final Acceptance to the Contractor.

3.11 WARRANTEE

A. When Final Acceptance is granted at the close of the spring planting season specified in this Section, the date of Final Acceptance shall start the required one-year warrantee for planting work. Plant replacements shall be made during the subsequent spring planting season during the following year. When Final acceptance is granted at the close of the fall planting season specified in this Section, the date of Final Acceptance shall start the required 1.5-year warrantee for planting work. Plant material replacements shall be made during the spring season in the calendar year 1.5 years after Final Acceptance.

B. At the end of the warrantee period, the Owner's Representative will perform a final inspection to determine whether any plant material replacements are required. Each plant shall be plumb, shall have a character that is natural for its species as determined by the Owner's Representative, and shall conform to the Acceptance Standards described in this Section. Plants found to be unacceptable shall be removed promptly from the site and replaced according to this Section.

C. At the end of the warrantee period, remove all above-ground tree stakes, guys, or anchors installed on trees during the course of the work of this contract.

D. All replacements shall be plants of the same kind and size specified in the PLANT LIST. The cost shall be borne by the Contractor, except for possible replacements due to vandalism or neglect on the part of others.

END OF SECTION

SECTION 33 0523

PIPE BURSTING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Work of this Section, as shown or specified, shall be in accordance with the requirements of the Contract Documents.

1.2 SECTION INCLUDES

A. Replacement of existing water pipe by pipe bursting methods.

1.3 RELATED SECTIONS

A. Division 1 Sections
B. Earthwork – Section 31 0000
C. Storm Sewerage - Section 33 4000

1.4 REFERENCES

A. ASTM D 1238-99
B. ASTM D 1505-98
C. ASTM D 790-00
D. ASTM D 638-99
E. ASTM D 1693-00
F. ASTM D 3350-99
G. ASTM D 618-99
H. ASTM D 2837-98
I. ASTMD 575

1.5 QUALIFICATIONS OF THE CONTRACTOR

A. The Contractor shall be certified by the pipe bursting system manufacturer as a fully trained user of the pipe bursting systems employed. Operation of the pipe bursting systems shall be performed by trained personnel. Such training shall be conducted by a qualified representative of the pipe bursting system manufacturers. The Owner may require that the Contractor provide certificates of training for any employee directly involved in the supervision or operation of the pipe bursting system.

B. Polyethylene pipe jointing shall be performed by personnel trained in the use of butt-fusion equipment and the recommended methods for new pipe connections. Personnel directly involved with installing the new pipe shall receive training in the proper methods for handling and installing the polyethylene pipe. Such training shall be conducted by a qualified representative of the fusion equipment manufacturer. Installation of other materials shall be performed by personnel qualified by the specific product manufacturer.

C. The Contractor shall hold the Owner and Engineer and any sub-consultants to the Engineer whole harmless in any legal action resulting from patent infringements.

1.6 QUALITY ASURANCE

A. The Contractor is solely responsible for quality assurance during the length of the project. The contractor is to be responsible for any costs associated with corrective measures required to replace or repair items not meeting the quality standards specified by the Owner.

1.7 SUBMITTALS

A. Video recorded documentation.

B. Certifications of training by the pipe bursting systems manufacturer stating that the operators have been fully trained in the use of the pipe bursting equipment by an authorized representative of the equipment manufacturer. Alternately the contractor may provide a letter of intent of training, to include course outline, from an authorized representative of the equipment manufacturer.

C. Detailed description of construction methods, procedures and sequencing including expected speed, pressures and pulling force.

D. List of all major bursting equipment to be used including make and model.

E. Locations and sizes of excavations.

F. Technical data for any lubricants to be used.

G. Contingency plans for the following potential conditions:
   1. Unforeseen obstruction(s) causing burst stoppage, such as unanticipated change(s) in host pipe material, repair section(s), concrete encasement(s) or cradle(s), or changes in direction not depicted on maps provided by the Owner.
   2. Substantial surface heave occurs due to the depth of the existing pipe vs. the amount of upsizing.
   3. Damage to the replacement pipe's structural integrity and methods of repair.
   4. Damage to other existing utilities.

1.8 DELIVERY, STORAGE AND HANDLING OF PIPE AND MATERIALS

A. The Contractor shall transport, handle, and store pipe and fittings as recommended by manufacturer.

B. New pipe and fittings that are damaged before or during installation shall be repaired or replaced, as recommended by the manufacturer or required by the Owner. The costs of such repair or replacement shall be borne by the Contractor and be accomplished prior to proceeding with the project.

C. The Contractor shall deliver, store and handle other materials as required to prevent damage. Materials that are damaged or lost shall be repaired or replaced by the Contractor at no additional expense to the Owner.

1.9 PIPE BURSTING TOOLS

A. The pipe bursting tool shall be designed and manufactured to force its way through existing pipe materials by fragmenting the pipe and compressing the old pipe sections into the surrounding soil as it progresses. The bursting unit shall generate sufficient force to burst and compact the existing pipeline. See manufacturer's specifications for what size tool should be used in what diameter of pipe, as well as parameters of what size tool for percentage of upsize allowed.

B. The pipe bursting tool shall be pulled through the pipe by a winch or rod located at the upstream receiving pit. The bursting unit shall pull the HDPE pipe with it as it moves forward. The bursting head shall incorporate a shield/expander to prevent collapse of the hole ahead of the new pipe insertion. The pipe bursting unit shall be remotely controlled.

C. The bursting action of the tool shall increase the external dimensions sufficiently, causing breakage of the existing pipe at the same time expanding the surrounding ground sufficiently to pull or pull/push in the new pipe without scarring, gouging or otherwise damaging new pipe.

PART 2 - PRODUCTS

2.1 PIPE:

A. High density polyethylene (HDPE) pipe as specified in Section 33 4000 – Storm Sewerage.

2.2 LUBRICANT:

A. Lubricant as approved by Owner.

PART 3 - EXECUTION

3.1 MATERIAL TESTING

A. The Contractor shall notify the Owner 48 hours before commencing the burst segment. The Contractor shall conduct an inspection of the new pipe to determine the condition of the pipe. Defects, which in the opinion of the Owner affect the integrity of strength of the pipe, shall be repaired or replaced by the Contractor at no additional cost to the Owner.

3.2 LOCATING UTILITIES

A. The Owner shall provide the Contractor with all documents relating to the location of utilities adjacent to the pipe to be replaced. The Contractor shall, prior to starting work, verify the location of all adjacent utilities. The minimum clearance from other

utilities shall be approximately two feet. The Owner may at its discretion reduce the minimum clearance. The Contractor shall expose all interfering and crossing utilities by spot excavating at the planar intersection of the pipe and removing the soil from around the utility. The cost of exposing these utilities shall be borne by the Contractor.

3.3 SUB-SURFACE CONDITIONS

A. The Owner will furnish the Contractor with all the necessary information listed in the Contract Documents. The Contractor shall verify this information in the field. All additional subsurface investigations deemed necessary by the Contractor to complete the work shall be included at no additional cost to the Owner. Copies of all reports and information obtained by the Contractor shall be provided to the Owner.

B. The minimum depth of cover over the installed pipe shall be ten times the amount of displacement from the diameter of the existing pipe or 3 feet (0.9lm) from the top of the existing pipe, whichever is greater. The Contractor may, with the prior approval of the Owner reduce the minimum depth of cover.

C. Settlement or heaving of the ground surface during or after construction will not be allowed. The Contractor is solely responsible for the costs for repairing any surface heaving unless specified otherwise in the contract documents.

3.4 PIPE JOINING

A. The HDPE pipe shall be joined by the butt-fusion method.

B. The butt-fused joint shall be true alignment and shall have uniform rollback beads resulting from the use of proper temperature and pressure. The joint shall be allowed adequate cooling time before removal of pressure. The fused joint shall be watertight and shall have tensile strength equal to or greater than that of the pipe. All joints shall be subject to acceptance by the Owner prior to insertion.

C. Terminal sections of pipe that are joined within the insertion pit shall be connected with an Electro Fusion Coupling (e.g. Central Plastics or equivalent). All connections shall be in conformance with the manufacturer's installation procedures.

3.5 PIPE INSPECTIONS

A. Prior to beginning work, the Contractor shall document by video recorder the interior condition of the existing pipes to be burst and provide recorded videos to the Owner. The Contractor shall utilize the videos to determine the proper equipment, methods and work effort needed to replace the existing pipes. Contractor shall determine all work necessary to complete the project including all requirements for pipe bursting and for open-cut excavation work necessary to complete the project.

B. Both prior to beginning work and following completion of pipe bursting the Contractor shall video record the interior condition of the existing sewer pipes at crossings with the pipes to be burst, and provide recorded videos to the Owner. Notify Owner of any damage to existing sewers.

C. Contractor shall excavate observation pits or otherwise expose installed new pipe where directed by Owner to allow inspection of pipe.

D. The Contractor shall cut out and replace defective joints at no additional cost to the Owner. Any section of the pipe with a gash, blister, abrasion, nick, scar, or other deleterious fault greater in depth than ten percent (10%) of the wall thickness (ASTM 585), shall be removed and replaced at no additional expense to the Owner. However, a defective area of the pipe may be cut out and the joint fused in accordance with the procedures stated above.

3.6 LUBRICATION

A. Lubrication shall be used if in the opinion of Contractor such lubrication is necessary to ensure the successful completion of the job. The Contractor shall use a lubricant approved by the Owner.

3.7 RESTORATION

A. Prior to backfilling excavations, the Contractor shall ensure that the new pipe is properly supported or bedded in accordance with Section 31 0000 – Earthwork. Bedding material shall be used immediately under the new pipe as support in order to avoid sagging after backfill and compaction.

B. The Contractor shall backfill all excavations and restore all disturbed pavements and landscaping to their original condition or better.

3.8 FIELD TESTING

A. After the new pipe is installed, the Contractor shall document by video recorder the interior condition of the entire length of new pipe and provide recorded videos to the Owner.

B. The new pipe shall be visibly free of defects, which may affect the integrity or strength of the pipe. If in the opinion of the Owner such defects exist the pipe shall be repaired or replaced at the Contractor's expense.

C. Any section of the pipe with a gash, blister, abrasion, nick, scar, or other deleterious fault greater in depth than ten percent (10%) of the wall thickness shall be removed and replaced at no additional expense to the Owner.

D. Flush, hydrostatic test and disinfect all water pipe in accordance with Section 33 1300 “Hydrostatic Testing and Disinfecting of Water System” prior to placing pipe in service.

3.9 VIDEO RECORDINGS

A. Post installation video recordings are to be submitted to the Owner for review prior to final payment. Should any portion of the inspection videos be of inadequate quality or coverage, as determined by the Owner, the Contractor will have that portion re-inspected at no additional expense to the Owner. All original videos remain property of the Owner. The Contractor may, at the discretion of the Owner retain a second copy.

End of Section

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SECTION 33 14 00

CHILLED WATER DISTRIBUTION

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Work of this Section, as shown or specified, shall be in accordance with the requirements of the Contract Documents.

1.2 SECTION INCLUDES

A. Pipe, fittings and accessories for below grade chilled water pipe.

B. Pipe bedding.

C. Below grade valves.

1.3 RELATED SECTIONS

A. Division 01 Sections

B. Earthwork – Section 31 0000.

1.4 REFERENCES

A. AWWA C111 - Rubber-gasket Joints for Ductile-iron and Gray-iron Pressure Pipe and Fittings.

B. AWWA C906 - Polyethylene (PE) Pressure Pipe and Fittings, 4” through 63” for Water Distribution.

C. Plastics Pipe Institute (PPI) Handbook of Polyethylene Pipe

D. Plastic Pipe Institute - Polyethylene Piping Systems Field Manual for Municipal Water Applications.

E. Plastics Pipe Institute TR-33 - Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe.

F. Plastics Pipe Institute TN-42 - Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Projects.

1.5 PROJECT RECORD DOCUMENTS

A. Submit to Owner and Engineer prior to final payment.

B. Accurately record actual locations of pipe runs, fittings, valves, and invert elevations.

1.6 QUALITY ASSURANCE

A. Pipe and Fittings: Marked with manufacturer’s name, nominal diameter, pressure rating, class or thickness, material, date and country of manufacture. Submit manufacturer’s certificate.

B. Valves: Marked on the bonnet or valve body with manufacturer’s name, year the valve casting was made, pressure rating.

1.7 SUBMITTALS

A. Product Data: Provide data on pipe, fittings, pipe restraints, adapters, valves and valve boxes, couplings, tracer wire and tracer wire accessories, and all other accessories.

B. PE Pipe Fusion Technician's Qualifications: Provide evidence of fusion, electrofusion, and mechanical coupling training within the past year. The training shall be on the equipment and pipe components to be utilized for this project.

C. Fusion Technician's Joint Report: Provide report including critical parameters of each fusion joint, as required by the manufacturer and these specifications, recorded either manually or by an electronic data logging device.

1.8 FIELD SAMPLES

A. Fusion Butt Joints: Make an acceptable test piece by each mechanic performing pipe welding. Allow the trial fusion to cool completely and then cut out test piece. Test piece to be 12 inches or 30 times the wall thickness in length (minimum) and 1 inch or 1.5 times the wall thickness in width (minimum). Bend the test piece until the ends of the piece touch. If the fusion fails at the joint, make a new trial, cool completely and test. Do not commence butt fusion of the pipe until a trial fusion has passed the bent strap test.

PART 2 – PRODUCTS

2.1 SITE PIPE, FITTINGS AND VALVES

A. High Density Polyethylene (HDPE) Pipe:
1. Pipe shall be made from PE compounds meeting the physical property requirements of ASTM D3350 having a minimum material designation code of PE 4710. The pipe shall meet the requirements of AWWA C906.
2. The outside diameter of the pipe shall be based upon the ductile iron pipe size (DIPS) sizing system for pipe 4" and larger, and copper tube size (CTS) for pipe 2" and smaller.
3. The pipe shall be rated for use at a pressure class of 160 psi and have a dimension ratio (DR) of 13.5.
4. Exterior of pipe shall be legibly marked, at intervals of no more than 5 feet, in accordance with the requirements of ASTM F714 and AWWA C906.

B. Pipe Insulation:
1. Polyurethane foam, spray applied or injected into the annular space between the carrier pipe and outer jacket with a minimum thickness of 1 inch. Insulation shall be rigid, 90- 95% closed cell polyurethane with 2.0 to 3.0 pounds per cubic foot density and coefficient of thermal conductivity (K-factor) of 0.16 and shall conform to ASTM C-591.
2. Outer jacket shall be extruded high-density polyethylene (HDPE) having a minimum wall thickness of 100 mils.

C. Insulation accessories:
1. Sealant for all exposed insulation at pipe ends shall be Canusa TubularStops - PLX.
2. Joint sleeves shall be Canusa CSCX shrink sleeves.

D. HDPE Fittings:
1. All fittings and adapters shall be made of PE4710, meet the requirements of AWWA C906 and have a DR and pressure rating equal to the pipe.
2. Mechanical Joint (MJ) Adapters: MJ adapters shall be made with sufficient through-bore length to be clamped in a butt fusion joining machine without the use of a stub-end holder All MJ adapters shall be supplied as a complete assembly with the gasket, bolts, nuts and gland ring from a single manufacturer.
3. Flange Adapters: Flange adapters shall have bolt-holes and bolt-circles conforming to ASME B-16.5 Class 150. Flange adapters shall be made with sufficient through-bore length to be clamped in a butt fusion joining machine without the use of a stub-

end holder. The sealing surface of the flange adapter shall be machined with a series of small v-shaped grooves to provide gasketless sealing, or to restrain the gasket against blow-out. All flange adapters shall be supplied as a complete assembly with all necessary components from a single manufacturer.

E. Gate Valves:
   1. Buried Gate Valves: Resilient-seated gate valves for water systems in accordance with the latest revision of AWWA C509. Cast iron body, bronze trim, single-wedge, non-rising stem with square nut and mechanical joint ends. Stainless steel bolts, studs and nuts for bonnet. Rated working pressure of 250 psi through 12-inch size for water service. Each valve shall be factory seat tested to 250 psig and shell tested to 500 psig.

2.2 BEDDING MATERIALS

A. For all excavation conditions bed pipe, fittings and valves in Cushion Sand, as shown on drawings and as specified in Division 2 Section “Earthwork”.

2.3 ACCESSORIES

A. Gate Valve Boxes: Cast iron three-piece screw type with minimum wall thickness of ¼ inch and barrel diameter of 5¼ inch; two feet of height adjustment with minimum 6 inch laps. Covers cast with the word “CHILLED WATER”. Box and cover bituminous coated.

B. Valve Box Base Adaptor: Rubber adaptor to seal base of 5-1/4” valve box to valve bonnet, and prevent shifting and settling of valve box. Adaptor Inc., #6 Base Adaptor or approved equal.

C. Valve Box Debris Plug: Cross-linked laminated heat-fused closed cell polyethylene with 350 lb test polypropylene handle, 6” thick, diameter to conform to 5-1/4” valve box. InFact, Mud Plug, or approved equal.

D. Joint accessories, including lubricant, for mechanical joint connections.

2.4 TRACER WIRE AND EQUIPMENT

A. Wire: All tracer wire to have HDPE insulation intended for direct bury installation, blue color unless otherwise noted.
   1. Standard Open Trench: Copper clad steel, #12 AWG, with minimum 450 lbs. break load and minimum 40 mil insulation thickness.
   2. Directional Drilling: Copper Clad Steel, #12 AWG, extra high strength with minimum 1,150 lb. break load and 40 mil insulation thickness.
   3. Pipe Bursting: Stranded Copper clad steel, #6 AWG 7x7, extreme strength with minimum 4,700 lb. break load and minimum 50 mil insulation thickness.

B. Connectors: Connectors shall be 3-way lockable connectors with mainline to lateral lug connectors specifically manufactured for use in underground trace wire installation; dielectric silicon filled to seal out moisture and corrosion,; installed in a manner so as to prevent any uninsulated wire exposure. Non locking friction fit, twist on or taped connectors are prohibited.

C. Access Boxes: All access boxes shall be specifically manufactured for tracer wire systems and shall be identified with “chilled water” cast into the cap and color coded. All access boxes to include a manually interruptible conductive/connective link between the terminal(s) for the trace wire connection and the terminal for the grounding anode wire connection. Below grade access boxes to be heavy duty and rated for roadway traffic.

D. Anodes: Drive-in style 1.5 lb. magnesium with HDPE cap and factory installed blue copper clad steel tracer wire.

E. Tape: As recommend by HDPE pipe manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that water pipe size, location and elevation are as shown on the drawings.

B. Thoroughly clean inside of pipe and fittings before installation.

C. Open and close gate valves to determine proper operation before installation. Tighten bolts and lubricate as per manufacturer's instructions. Keep valves fully open or shut.

D. Verify required bury depth for valve boxes.

3.2 SCHEDULE

A. Schedule work involving disruption of water service with Cornell Utilities Department a minimum five (5) working days prior to beginning work. Do not interrupt existing service without authorization from Cornell Utilities Department.

3.3 TRENCH EXCAVATION AND BEDDING

A. Excavate pipe trench in accordance with Section 31 0000 "Earthwork". Hand trim excavation for accurate placement of pipe to elevations indicated.

B. Compact subgrade as necessary.

C. Place bedding material at trench bottom across entire width of trench in such thickness that a minimum of 6 inches (8 inches in rock) will be under the bottom of the pipe and the bottom quadrant of the pipe will be below the level surface of the bedding material each side of the pipe barrel.

D. Shape the bed to receive the pipe. Work bedding material under the pipe using hand tools or mechanical vibratory tapping equipment to completely fill all void spaces and provide continuous support or pipe and fittings.

E. Remove any temporary blocking from trench in conjunction with installation of bedding material.

3.4 PIPE AND FITTINGS

A. Maintain minimum 6-inch separation of pipe to all other utilities or structures.

B. Install pipe to indicated elevation to within tolerance of 3 inches.

C. Install PE pipe and fittings in accordance with the requirements of AWWA C906, the PPI Handbook of Polyethylene Pipe, and AWWA Manual of Practice M55. The fused joints shall be watertight and shall have a tensile strength equal to or greater than that of the pipe.
   1. Butt Fusion: The pipe shall be joined by the butt fusion procedure outlined in PPI TR-33. All fusion joints shall be made in compliance with the pipe or fitting manufacturer's recommendations. Fusion joints shall be made by qualified fusion technicians per PPI TN-42.
   2. Electrofusion: Electrofusion joining shall be done in accordance with the manufacturers recommended procedure. Other sources of electrofusion joining information are in PPI TN-34. The process of electrofusion requires an electric source, a transformer, commonly called an electrofusion box that has wire leads, a method to read electronically (by laser)or otherwise input the barcode of the fitting, and a fitting that is compatible with the type of electrofusion box used. The electrofusion box must be capable of reading and storing the input parameters and

the fusion results for later download to a record file. Qualification of the fusion technician shall be demonstrated by evidence of electrofusion training within the past year on the equipment to be utilized for this project.

3. Mechanical connection of PE pipe to valves, and fittings where shown, shall use mechanical joint adapters in conformance with the PPI Handbook of Polyethylene Pipe, and AWWA Manual of Practice M55.
4. Provide flange adapters where shown and install in conformance with the PPI Handbook of Polyethylene Pipe, and AWWA Manual of Practice M55.
5. Joint Recording - The critical parameters of each fusion joint, as required by the manufacturer and these specifications, shall be recorded either manually or by an electronic data logging device. All fusion joint data shall be included in the Fusion Technician's joint report.
6. Seal all exposed insulation at all pipe ends. Apply additional insulation as necessary. Close and provide a watertight seal all field insulated joints using successive heat shrink sleeves over the insulated joint.

D. Lay pipe flat or slope up to building. Do not create high points in the pipe.

E. Route pipe in direct route between fittings.

F. Install flushing taps at locations as necessary to permit testing of system.

G. Establish elevations of buried pipe and pipe bored or jacked under highways, to ensure not less than 4.0 feet of cover, unless shown otherwise.

H. Close all open ends or fittings at the end of each construction day with watertight expandable plugs. Do not use plywood, burlap, plastic or any other non-watertight covers.

I. Backfill trenches in accordance with Section 31 0000 "Earthwork".

3.5 PROTECTIVE WARNING TAPE AND TRACER WIRE

A. Install tracer wire attached to pipe and continuous warning tape at 12 inches below final grade.

B. Install tracer wire connectors at tees. Install at-grade and hydrant tracer wire access boxes and anodes. Make all necessary connections of wires and jumpers.

C. Owner to test, approve and accept tracer wire system prior to final payment. Contractor shall correct any deficiencies in tracer wire system prior to acceptance by Owner.

3.6 VALVES

A. Confirm guard valve falls within one homogeneous surface material with a minimum 12" separation to any curbing.

B. Set gate valves and bed as described herein.

C. Center, plumb and straighten valve box over valve. Install valve box base adaptor and debris plug per manufacturer's instructions.

D. Adjust all valve boxes to be flush with finish grades in landscaped areas and ½ inch below finish grade in pavements.

3.7 FLUSHING AND TESTING OF HDPE WATER SYSTEMS

A. Perform testing after piping has been installed and backfilled in trench, and all restraints have been installed.

B. Provide and attach required equipment and materials, including water, sampling taps, tapped plugs, and hoses to perform flushing and testing.

C. Slowly fill pipe with clean potable chlorinated water from an existing fire hydrant, or by opening a divisional valve at the connection point on the existing system. For hydrant supplies, the connection shall be equipped with an RPZ backflow device. Expel air from the line through taps made at the high points or end of the pipe.

D. Flush all pipe at a minimum velocity of 3.0 feet per second for 3 full turnovers of the water volume or until water flows clear, whichever is longer. All dead ends and stubs must be flushed. Coordinate and open one division valve, or temporary terminating valve, at a time as necessary to obtain minimum velocity.

E. Operation of divisional valves shall be performed by Cornell Utilities Department staff or under their direct supervision.

F. Allow a minimum 8 hours between filling and pressurizing the test section to allow the piping to thermally stabilize.

G. The target test pressure at the lowest point along the test section shall be 1.5 times the pipe pressure class, or based on the pressure rating of the lowest pressure rated fitting or other component in the test section, whichever is less. Pressure shall be observed at the pressurizing pump.

H. Pressurize and maintain the pressure in the test section at the target test pressure for a maximum or 3 hours. Test is acceptable and leakage is not indicated if pressure remains within 5% of the target test pressure for 1 full hour. If the test in not completed for any reason, the test section shall be depressurized for at least 8 hours before starting the next testing sequence. Under no circumstances shall the total time for initial pressurization and time at test pressure exceed 8 hours.

I. Observe piping for visible leaks or pipe movement. If leakage is observed, complete rupture may be imminent. Evacuate persons from the area of any leak and depressurize the piping immediately.

End of Section

SECTION 33 30 00

SANITARY SEWERAGE

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Work of this Section, as shown or specified, shall be in accordance with the requirements of the Contract Documents.

1.2 SECTION INCLUDES

A. Demolition, removal and abandoning of existing utilities.
B. Pipe, fittings, and accessories for sanitary sewer mains.
C. Cleanout access.

1.3 RELATED SECTIONS

A. Division 01 Sections
B. Earthwork – Section 310000.

1.4 REFERENCES

A. ASTM F1417-92(1998) Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air.
B. ANSI/ASTM D3034 - Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
C. ASTM D2241 - Standard specification for poly vinyl chloride (PVC) plastic pipe (SDR-PR).
D. ASTM A536 – Ductile Iron Castings

1.5 SUBMITTALS

A. Predemolition Photographs or Video: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by building and site demolition operations.

B. Product data for sewer pipe, cleanouts, traps and manholes.

C. Record Drawings: Showing pipe sizes, locations, and elevations. Include details of underground connections.

D. Test Reports: Indicate results comparative to specified requirements.

1.6 REGULATORY REQUIREMENTS

A. Conform to applicable Local and State codes for disposal of debris.

B. Submit to Owner a signed fill agreement or property owner release for deposit of debris material disposed of off site.

C. Locate, identify, and protect utilities that remain, from damage. Be assured as to the location and position of gas, water, sewer, electric, telephone services and mains, culverts and other conduits that may be affected by the construction and notify the respective authorities in charge of same of the work in the vicinity. CALL Dig Safely New York (former Underground Facilities Protective Organization) 811 BEFORE STARTING EXCAVATION OPERATIONS. The Contractor will be held strictly responsible for the cost of repairs or replacement of all utilities and other conduits damaged directly by his forces or indirectly by failure to provide proper protection or support of the same. The Contractor will also be held responsible for damages to others caused by utility lines damaged either directly or indirectly by his operations. Comply with all rules and regulations cited in 16 NYCRR Part 753 – Protection of Underground Facilities.

1.7 UTILITY INTERRUPTIONS AND CONNECTIONS

A. Coordinate the shutdown details for all utilities with Cornell University Utilities Department. A minimum of four weeks notice to Cornell is required for shutdown scheduling and proper notice to those effected.

B. Water valves will only be operated by Cornell personnel.

1.8 MAINTENANCE AND PROTECTION OF TRAFFIC

A. Do not close or obstruct public highways without written authorization from the controlling authority.

B. When road or lane closures are required comply with the requirements of the Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 Edition for barricades and signage

C. Notify the Tompkins County Emergency Control Center at (607)273-7288 at the beginning and end of a restriction on any highway.

D. Schedule work so that all travel lanes in each direction are open when the Contractor's operations are closed down or substantially closed down.

1.9 DELIVERY, STORAGE AND HANDLING

A. Do not store plastic pipe or fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

1.10 PROJECT RECORD DOCUMENTS

A. Accurately record actual location of pipe runs, fittings, termination of laterals, couplings, lateral connections to the main, and invert elevations.

B. Submit to City of Ithaca, Owner and Engineer prior to final payment.

1.11 PROJECT CONDITIONS

A. Site Information: Perform site survey, research Owner's and City's utility records, and verify existing utility locations.

B. Sewer Opening Permit: Obtain and pay for the sewer permit from the City of Ithaca prior to opening, disturbing or altering any public sewer or lateral.

C. Locate existing sewer laterals to be closed and abandoned.

D. Existing Utilities: Do not interrupt public utilities unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Cornell Utilities Department not less than four weeks in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Owner's written permission.
   3. Coordinate work with the location, alignment and elevation of water mains and storm sewers.
   4. Verify pressure and vacuum testing procedures with Cornell Utilities Department.

1.12 QUALITY ASSURANCE

A. Pipe and Fittings: All plastic sewer pipe and fittings marked with manufacturer's name, nominal diameter of opening, material designation "PVC", the legend "Type PSM SDR 35", identity of standard.

PART 2 - PRODUCTS

2.1 PLUGS FOR ABANDONED PIPE

A. Mechanical Plugs: Expandable metal or plastic plug utilizing natural rubber “O” ring with wing nut or hex nut adjustment and suitable for long-term buried applications.

2.2 PIPE AND FITTINGS

A. Plastic Pipe and Fittings: ANSI/ASTM D3034, Type PSM, Poly (Vinyl Chloride) (PVC) material, SDR 35; nominal diameter as shown on the drawings; bell-and- spigot style rubber-ring sealed gasket joint.

2.3 SPECIAL PIPE COUPLINGS AND FITTINGS

A. Sleeve-Type Pipe Couplings: ASTM C 1173, rubber or elastomeric sleeve and band assembly fabricated to mate with OD of pipes to be joined, for nonpressure joints.

B. Sleeve Material for Plastic Pipe: ASTM F 477, elastomeric seal.

C. Sleeve Material for Dissimilar Pipe: Compatible with pipe materials being joined.

D. Bands: Stainless steel, at least one at each pipe insert.

2.4 PRECAST CONCRETE MANHOLE

A. Sections: Reinforced precast concrete in accordance with ASTM C478 designed for minimum HS25 loading. Utilize rubber -O- rings or butyl rubber sealant for jointing between sections. Eccentric cone or cover slab as shown on Drawings. All manholes 48 inch interior dimension unless noted otherwise. Top of eccentric cone to match grade ring dimension.

2.5 MANHOLE FRAME AND COVER

A. Frame and Cover: Cast or ductile iron, heavy duty, designed for minimum HS25 loading, 24 inch clear opening by 6 to 9 inch riser, cover with non-penetrating pick holes and neoprene gasket cemented into a machined groove, checkered top design with lettering “SANITARY” cast into cover.

2.6 MANHOLE STEPS

A. Steps: Copolymer polypropylene encapsulated steel, in accordance with ASTM C478, spaced at 12 inches on-center and formed integral with manhole section .

2.7 RESILIENT CONNECTOR

A. Connector: Watertight pipe to manhole boot seal, in accordance with ASTM C-923, to match outside diameter of sewer pipe. Stainless steel sleeve, take-up clamps and screws.

2.8 MANHOLE COATINGS

A. Manhole Sections and Concrete Floor: Water base acrylic coating inside and out on all sections and grouted joints and on interior concrete floor and channel. As manufactured by ConSeal Concrete Sealants, Inc., CS-55 or equal.

2.9 CONFIGURATION

A. Sanitary Sewer Manholes:
   1. Align steps with eccentric riser sections.
   2. Shape, clear inside dimensions, and design depth as shown on Drawings.
   3. Provide pipe knockouts and openings as shown on Drawings.

2.10 BEDDING MATERIALS

A. Pipe and Fittings: All pipe and fittings bedded and encased in bedding stone, as specified in Division 31 Section “Earthwork”.

B. Sanitary Sewer Manholes: Bedded in bedding stone, as specified in Division 31 Section “Earthwork”.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify main size, location and elevations of connection to existing system are as shown on Drawings.

B. Verify that intended locations and elevations of pipe runs shown on Drawings, will not conflict with storm sewerage and water mains.

C. Verify minimum separation requirements at crossings with other utilities.

3.2 PREPARATION

A. Site Inspection
1. Prior to work of this Section, carefully inspect the entire site and all objects designated to be removed and to be preserved.
2. Coordinate and complete a walk-through of the site with Landscape Architect prior to site clearing to identify and tag plant life to be protected and preserved.
3. Locate all existing utility lines and determine all requirements for disconnecting and capping.
4. Locate all existing active utility lines traversing the site and determine the requirements for protection.

B. Clarification
1. The drawings do not purport to show all objects existing on the site.
2. Before commencing work of this Section, verify by inspection all objects to be removed and all objects to be preserved.

C. Scheduling
1. Schedule all work in a careful manner with all necessary consideration for neighbors and the public.
2. Avoid interference with the use of, and passage to and from, adjacent buildings and facilities.

D. Disconnection of Utilities: Before starting site operations, disconnect or arrange for the disconnection of all utility services designated to be removed, performing all such work in accordance with the requirements of the utility authority.

E. Protection of Utilities: Preserve in operating condition all active utilities traversing the site and designated to remain.

F. Carefully review clearing work required adjacent to existing structures and subgrade foundations.

3.3 PROTECTION

A. Locate, identify, and protect utilities and existing improvements that remain from damage.

B. Protect existing trees and other vegetation indicated to remain in place against unnecessary cutting, breaking, or skinning and bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within drip line, excess foot or

vehicular traffic, or parking of vehicles within drip line. Erect and maintain protective fencing for trees and other vegetation.

C. Protect survey benchmarks and property pins from damage or displacement.

D. Protect existing above and below grade structures designated to remain from damage. Correct any damage at Contractor's expense.

3.4 PIPE BEDDING

A. Excavate in accordance with Division 31 Section "Earthwork" for work of this Section. Hand trim excavation for accurate placement of pipe to elevations indicated.

B. Place bedding material at trench bottom across entire width of trench in such thickness that a minimum of 6 inches will be under the bottom of the pipe.

C. Shape the bed to receive the pipe, Work bedding material under the pipe to provide continuous support.

3.5 PIPE AND FITTINGS

A. Maintain minimum 10 feet horizontal separation of sewer main from water mains. Maintain minimum 18 inch vertical separation of sewer main and water main at crossings.

B. Install plastic sewer pipe, fittings, and accessories in accordance with ASTM D2321 and manufacturer's instructions.

C. Install pipe in straight line between manholes and fittings to grades indicated on drawings with unbroken continuity of invert. Horizontal dimensions indicated for piping are to centerline of manholes or fittings. Place bell ends of piping facing upstream.

D. Use proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. Lift or roll pipe into position, do not drop or drag pipe over prepared bedding material.

F. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

G. Shore pipe to required position and retain in place until after placing and compacting of adjacent backfill. Ensure pipe remains in correct position and to required slope.

A. Close all open pipe ends and fittings at the end of each construction day with watertight expandable plugs. Do not use plywood, burlap, plastic and other non-watertight covers.

B. Establish elevations of buried piping to ensure not less than 4.5 feet of cover, unless shown otherwise.

C. Backfill trench in accordance with Division 31 Section "Earthwork".

3.6 FIELD QUALITY CONTROL

A. Clear interior of piping and structures of dirt and superfluous material as work progresses.

B. Pressure Test:
1. Test gravity sewers by use of air equipment. Provide all labor, materials and equipment for the test.
2. For the section of main being tested, there may be a permissible drop of 0.5 psi gage from 3.5 to 3.0 psi gage in the minimum times listed in the following table:

SPECIFICATION TIME REQUIRED FOR A 0.5 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED

Pipe Dia. (in)	Min. Time (min. sec.)	Length for Min Time (ft.)	Time for Longer Length (sec.)	Specification Time for Length (L) Shown (min:sec)			
				100 ft	200 ft	300 ft	400 ft
4	1:53	597	.190L	1:53	1:53	1:53	1:53
6	2:50	398	.427L	2:50	2:50	2:50	2:51
8	3:47	298	.760L	3:47	3:47	3:48	5:04
10	4:43	239	1.187L	4:43	4:43	5:56	7:54
12	5:40	199	1.709L	5:40	5:42	8:33	11:24

C. If testing and inspection indicate defects, correct such defects and retest.

End of Section

SECTION 33 40 00

STORM SEWERAGE

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Work of this Section, as shown or specified, shall be in accordance with the requirements of the Contract Documents.

1.2 SECTION INCLUDES

A. Demolition, removal and abandoning of existing utilities.
B. Storm sewer piping, fittings, and accessories.
C. Underdrain system for pavements.
D. Pre-cast concrete drainage inlets and manholes, frames, grates and covers.
E. Rip-rap stone filling and filter fabric.

1.3 RELATED SECTIONS

A. Division 1 Sections.
B. Earthwork – Section 310000.

1.4 REFERENCES

A. ASTM A536 – Ductile Iron Castings
B. ASTM D3350 - Polyethylene Plastic Pipe.
C. ANSI/ASTM D3034 - Type PSM Poly Vinyl Chloride (PVC), SDR 35, Solid and Perforated Sewer Pipe.
D. ASTM F405 - Corrugated Polyethylene Tubing and Fittings.
E. AASHTO M294 - Strength Requirements for ASTM D3350 Polyethylene Plastic Pipe and Fittings, 12 to 36 inch diameter.
F. AASHTO M252 - Strength Requirements for ASTM D3350 Corrugated Polyethylene Drainage Tubing.

1.5 PROJECT RECORD DOCUMENTS

A. Accurately record actual locations of pipe runs, fittings, connections, drainage inlets, and invert elevations.

B. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 COORDINATION

A. Coordinate work with location of building drains, site drain inlets and alignment of curbing.

B. Coordinate work with location and alignment of existing drainage structures.

1.7 SUBMITTALS

A. Predemolition Photographs or Video: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by building and site demolition operations.

B. Product data for storm sewer pipe and tubing.

C. Shop Drawings: Include plans, elevations, details and attachments for precast concrete structures including flow inverts, frames, covers and grates.

D. Record Drawings: Showing structures and other structures, pipe sizes, locations, and elevations. Include details of underground structures and connections.

1.8 REGULATORY REQUIREMENTS

A. Conform to applicable Local and State codes for disposal of debris.

B. Submit to Owner a signed fill agreement or property owner release for deposit of debris material disposed of off site.

C. Locate, identify, and protect utilities that remain, from damage. Be assured as to the location and position of gas, water, sewer, electric, telephone services and mains, culverts and other conduits that may be affected by the construction and notify the respective authorities in charge of same of the work in the vicinity. CALL Dig Safely New York (former Underground Facilities Protective Organization) 811 BEFORE STARTING EXCAVATION OPERATIONS. The Contractor will be held strictly responsible for the cost of repairs or replacement of all utilities and other conduits damaged directly by his forces or indirectly by failure to provide proper protection or support of the same. The Contractor will also be held responsible for damages to others caused by utility lines damaged either directly or indirectly by his operations. Comply with all rules and regulations cited in 16 NYCRR Part 753 – Protection of Underground Facilities.

1.9 UTILITY INTERRUPTIONS AND CONNECTIONS

A. Coordinate the shutdown details for all utilities with Cornell University Utilities Department. A minimum of four weeks notice to Cornell is required for shutdown scheduling and proper notice to those effected.

B. Water valves will only be operated by Cornell personnel.

1.10 MAINTENANCE AND PROTECTION OF TRAFFIC

A. Do not close or obstruct public highways without written authorization from the controlling authority.

B. When road or lane closures are required comply with the requirements of the Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 Edition for barricades and signage

C. Notify the Tompkins County Emergency Control Center at (607)273-7288 at the beginning and end of a restriction on any highway.

D. Schedule work so that all travel lanes in each direction are open when the Contractor's operations are closed down or substantially closed down.

1.11 ENVIRONMENTAL REQUIREMENTS

A. Maintain materials and surrounding air temperature to minimum 50 degrees F prior to, during, and 48 hours after completion of masonry work.

PART 2- PRODUCTS

2.1 PLUGS FOR ABANDONED PIPE

A. Mechanical Plugs: Expandable metal or plastic plug utilizing natural rubber "O" ring with wing nut or hex nut adjustment and suitable for long-term buried applications.

2.2 STORM SEWER PIPE AND ACCESSORIES

A. PVC Pipe and Fittings: ANSI/ASTM D3034, Type PSM, Poly Vinyl Chloride (PVC) material, SDR 35; nominal diameter as shown on the drawings; and bell and spigot style rubber ring sealed gasket joint.

B. HDPE Corrugated Plastic Pipe:

1. ASTM D3350 with strength requirements of AASHTO M252 for sizes 4 to 10 inch diameter and AASHTO M294 for sizes 12 to 36 inch diameter; smooth interior. Sizes and lengths as shown on Drawings.
2. Water tight pipe ends, coupling bands or external snap couplers same material as pipe.

C. PVC Underdrain Pipe and Fittings: ANSI/ASTM D3034, Type PSM, Poly Vinyl Chloride (PVC) material, solid and perforated pipe; SDR 35; nominal diameter as shown on the drawings; and bell and spigot style rubber ring sealed gasket joint.

D. HDPE Pipe for Trenchless Installation: Pipe meeting the physical property requirements of ASTM D3350 having a minimum material designation code of PE 4710. The outside diameter of the pipe shall be based upon the ductile iron pipe size (DIPS) sizing system. The pipe shall be rated for use at a pressure class of 100 psi and have a dimension ratio (DR) of 21.

E. Backwater Valves: Galvized cast iron body with bronze flapper, hub type, specifically manufactured to protect against backwater surges in gravity applications where sewer lines discharge into manholes. J.R. Smith Fig. 7070C-G or approved equal.

2.3 DRAINAGE INLETS, CONTROL STRUCTURES AND MANHOLES

A. Reinforced pre-cast concrete drainage inlets and control structures in accordance with ASTM C478. AASHTO HS-25 design loading. Shape and inside dimensions in accordance with requirements shown on Drawings. Base and riser sections to have a minimum 6 inch thickness and lengths as necessary to meet invert and rim elevations. Utilize rubber -O- rings or Butyl Sealant for jointing between sections. Openings for pipes shall be formed or cored, and equipped with resilient connectors during fabrication.

B. Reinforced pre-cast concrete manholes in accordance with ASTM C478. AASHTO HS-25 design loading. Utilize rubber -O- rings or Butyl Sealant for jointing between sections. Copolymer polypropylene encapsulated steel manhole steps, in accordance with ASTM C478, spaced at 12 inches on center and formed integral with manhole section. Align steps with eccentric riser section, clear inside dimension to be 48 inches unless noted otherwise.

C. Resilient Connector: For all storm manholes and Watertight pipe to structure boot seal, in accordance with ASTM C-923, to match outside diameter of sewer pipe. Stainless steel sleeve, take-up clamps and screws.

D. Heavy Duty Frame and Grate: Cast or ductile iron, heavy duty, designed for minimum HS25 loading. Uniform quality, close grained, free from blow holes, shrinkage, cracks and other defects. Plugging of defective castings not permitted. Grates to seat in any position without rocking. Grates as specified on Drawings.

E. Heavy Duty Manhole Frame and Cover: Cast or ductile iron, heavy duty, designed for minimum HS25 loading, 24 inch clear opening by 6 to 9 inch riser, cover with non-penetrating pick holes, checkered top design with lettering “STORM” cast into cover. Covers to seat in any position without rocking. Covers as specified on Drawings.

F. Grade Rings: Pre-cast concrete only.

2.4 TRENCH DRAINS

A. Slab Trench Drain: Pre-fabricated interlocking units, polyester polymer concrete body, minimum 1/8” thick stainless steel rails integrally cast in body at fabrication, 4” nominal clear opening width, 4” bottom outlet, with end caps and all other necessary components. ACO Drain SlabDrain H100KS-8 or appoved equal.

B. Site Trench Drain: Pre-fabricated interlocking units, polyester polymer concrete body, sloped channel, minimum 3/32” thick stainless steel rails integrally cast in body at

fabrication, 4" nominal clear opening width, 4" bottom outlet, with end caps and all other necessary components. ACO Drain KlassicDrain KS100 or appoved equal.

C. Trench Grate: Uncoated ductile iron, ADA compliant, Load Class C, 4" nominal wisth, with locking mechanism and manufactured specificall for use with applicable trench drain. ACO Drain Type 476D or appoved equal.

2.5 BEDDING MATERIALS

A. Storm Sewer Pipe: All storm sewer pipe bedded and encased in bedding stone as specified in Division 31 Section "Earthwork".

B. Underdrain Pipe: All underdrain pipe bedded and encased in bedding stone, as specified in Division 31 Section "Earthwork".

2.6 COUPLINGS AND SLEEVES

A. Coupling: Rubber or elastomeric sleeve and stainless steel band assembly fabricated to match outside diameters of pipes to be joined.

B. Sleeves: ASTM C425, rubber for vitrified clay pipe; ASTM C443, rubber for concrete pipe; ASTM C564, rubber for cast-iron soil pipe; and ASTM F477, elastomeric seal for plastic pipe. Sleeves for dissimilar or other pipe materials shall be compatible with pipe materials to be joined.

C. Bands and Clamp Housing: 301 stainless steel, one at each pipe insert.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that inside dimensions of drainage inlets, pipe slopes and invert elevations are as shown on Drawings.

B. Verify that existing underdrain systems are correctly reconnected to the storm sewer system.

3.2 PREPARATION

A. Site Inspection
1. Prior to work of this Section, carefully inspect the entire site and all objects designated to be removed and to be preserved.
2. Coordinate and complete a walk-through of the site with Landscape Architect prior to site clearing to identify and tag plant life to be protected and preserved.
3. Locate all existing utility lines and determine all requirements for disconnecting and capping.
4. Locate all existing active utility lines traversing the site and determine the requirements for protection.

B. Clarification
1. The drawings do not purport to show all objects existing on the site.
2. Before commencing work of this Section, verify by inspection all objects to be removed and all objects to be preserved.

C. Scheduling
1. Schedule all work in a careful manner with all necessary consideration for neighbors and the public.
2. Avoid interference with the use of, and passage to and from, adjacent buildings and facilities.

D. Disconnection of Utilities: Before starting site operations, disconnect or arrange for the disconnection of all utility services designated to be removed, performing all such work in accordance with the requirements of the utility authority.

E. Protection of Utilities: Preserve in operating condition all active utilities traversing the site and designated to remain.

F. Carefully review clearing work required adjacent to existing structures and subgrade foundations.

3.3 PROTECTION

A. Locate, identify, and protect utilities and existing improvements that remain from damage.

B. Protect existing trees and other vegetation indicated to remain in place against unnecessary cutting, breaking, or skinning and bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within drip line, excess foot or vehicular traffic, or parking of vehicles within drip line. Erect and maintain protective fencing for trees and other vegetation.

C. Protect survey benchmarks and property pins from damage or displacement.

D. Protect existing above and below grade structures designated to remain from damage. Correct any damage at Contractor's expense.

3.4 EXCAVATION

A. Excavate for trenches and structures in accordance with Division 31 Section "Earthwork".

3.5 BEDDING

A. For storm sewer pipe, place bedding material at trench bottom across entire width of trench in such thickness that a minimum of 6 inches will be under the bottom of the pipe.

B. For underdrain tubing, place a minimum of 4 inches of bedding material beneath the invert. Place balance of aggregate encasement to depth and width shown on the Drawings.

3.6 PIPE AND TUBING

A. Install corrugated polyethylene plastic pipe and couplings in accordance with manufacturer's instructions.

B. Install plastic perforated pipe, in accordance with ASTM D2321 and manufacturer's instructions.

C. Lift or roll pipe in position. Do not drop or drag pipe over prepared bedding. Lay pipe at down-stream end and progress upstream. Begin work at existing catch basin.

D. Shore pipe to required position; retain in place until after compaction of adjacent fills. Ensure pipe remains in correct position and to required slope.

E. Lay pipe to invert elevations shown on Drawings.

F. Refer to Division 31 Section "Earthwork" for backfill requirements. Do not displace or damage pipe when compacting.

3.7 DRAINAGE STRUCTURES AND HEADWALLS

A. Place pre-cast concrete structures on leveled bedding stone and at required elevation to maintain pipe invert elevations shown on Drawings.

B. Install pipe flush with the inside face of structure wall. Seal voids between pipe and knockout with cement grout inside and outside of structure.

C. Do not begin backfilling until cement grout seal is completely set.

D. Maintain drainage by installing frame and grate flush with temporary finished grade and bring to final elevation at time of paving with pre-cast concrete grade ring and grout frame permanently in place.

E. Mount frame level in grout to required elevations and secured to top of structure. Align inlet frames to match the line of curbing. Set grate in frame and correct deficiency in casting such that grate will seat in position without rocking.

F. Install poured concrete invert in drainage inlets and manholes where shown to dimensions shown on Drawings. Use a stiff mix and finish smooth to prohibit standing water.

G. Verify installation of manhole steps to avoid conflict with inlet and outlet pipes.

3.8 ERECTION TOLERANCES

A. Maximum Variation from Intended Elevation of Culvert Invert: 1/2 inch.

B. Maximum Offset of Pipe from True Alignment: 3 inches.

C. Maximum Variation in Profile of Structure from Intended Position: 1/8 percent.

3.9 FIELD QUALITY CONTROL

A. Inspect interior of pipe to determine whether line displacement or other damage has occurred. Make inspection after pipe has been installed and backfill is in place, and again at completion of work.

B. If inspection indicates poor alignment, displaced or collapsed pipe, or other defect, correct such defect and re-inspect.

End of Section