For construction contracts greater than $20,000

East Gym Addition - General Construction

C071086A

April 17, 2024

Volume II

Binghamton University
4400 Vestal Parkway East
Binghamton, New York 13902

Date: April 17, 2024

Project Number: **C071086A**
Project Name: **East Gym Addition – General Construction**
Agency/Div. Code: **28020**

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SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Basic Mechanical Requirements specifically applicable to Division 23 in addition to Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 General Requirements and Supplemental Requirements Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

A. All Division 23 section noted included in the Project Manuals.

1.3 REGULATORY REQUIREMENTS

A. Products requiring electrical connection: listed and classified by Underwriters Laboratories, as suitable for the purpose specified and indicated.

1.4 DEFINITIONS

A. 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.

B. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

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

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

E. Finished Spaces: Spaces other than mechanical, plumbing and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, space above ceilings, unexcavated spaces, crawl spaces, and tunnels.

F. Furnish: Contractor shall supply (purchase) item and turn over to others for installation.

G. Install: Others shall purchase item and the contractor shall place item in position for service and or use.

H. Provide: Contractor shall furnish (purchase) and completely install item.

I. Owner: Binghamton University

J. Salvage: Remove unused existing equipment where accessible and offer salvage material to the owner. Owner shall have first right of refusal of salvageable materials removed from the building. Materials not claimed by the owner shall become the property of the contractor. The contractor shall dispose of material not retained by the owner in a lawful and legal manner away from the site.

K. Storage: To provide a safe warehousing location to protect equipment and components that are to be implemented as part of the project. This includes but not limited to existing items to be relocated by the owner/contractor and items purchased by the owner/contractor.

1.5 PERFORMANCE

A. All work shall be performed in cooperation with the Owner, Architect and other separate contractors. The contractor shall coordinate work with the construction schedule established by the Owner and Architect and shall immediately report any delays in materials receipt including circumstances causing the delays.

1.6 SUBMITTALS

A. Refer to Division 1
   1. Submittal procedures.
   2. Shop Drawings and Samples.
   3. Coordination Drawings.

B. Product Data: For products listed under Part 2 of Division 23 technical specifications.

C. Welding certificates.

D. Coordination Drawings: Provide drawings to include but not limited to:
   1. Location of access panel and door in ceilings, walls and floors.
   2. Drawings to coordinate space above ceilings with other trades.
   3. Drawings coordinating light fixtures.
   4. Drawings coordinating sprinklers.
   5. Drawings coordinating ductwork.
   6. Drawings coordinating piping.
   7. Drawings coordinating mechanical rooms noting, equipment pads, equipments, piping, ductwork, starters, etc.
   8. Provide plans, sections, and wall elevations for all mechanical and equipment rooms.

E. Drawings coordinating mechanical rooms noting, equipment pads, equipment, piping, ductwork, starters, etc.

F. Provide plans, sections and wall elevations for all mechanical and equipment rooms.

G. Submit to architect/engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.

H. Submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to the architect/engineer for product data.

I. Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information specific to this project. Submittals that are not properly marked with all pertinent information identified will be returned.

J. Submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to the architect/engineer for product data.

K. Product data: Published literature: indicate dimensions, weights, capacities, ratings, gages and finishes of materials, electrical characteristics, and connection requirements.

L. Shop drawings: Indicate assembly, dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics and connection requirements.

M. Manufacturer's instructions: Include installation instructions.

N. Maintenance data: Include instructions for lubrication, replacement parts, motor and drive replacement, spare parts lists, and wiring diagrams.

O. In addition, the submittal shall bear the project name, the contractor's name, the date reviewed by the contractor, the contractor's control number (if applicable), and a stamp with the contractor's signature certifying that the item has been reviewed and it complies with the requirements of the contract documents.

P. Any submittals not clearly marked as indicated above will be returned to the contractor for resubmission.

1.7 CLOSEOUT SUBMITTALS

A. Provide the following items to be used as facility Operation and Maintenance Manual. Minimum of one (1) hard copy and one (1) electrical copy unless note elsewhere in the project requirements.
   1. Product Date: Provide one copy of final approved product data for products listed under Part 2 of Division 23 technical specifications
   2. Manufacturer's instructions: Include installation instructions
   3. Manufacturer's data: Include instructions for lubrication, replace parts, motor and drive replacement, spare parts list, and wiring diagrams.
   4. Include a table of contents with bookmark for each product type in electronic format within the O&M Manual. Table of Contents shall be hyper link tot eh bookmakers int eh electronic documents to find equipment.

B. Upon completion of installation, prior to Owner accepting portions of building and equipment for operational use, instruct the Owner's operating personnel in the operation of the systems and equipment. Instruction shall be performed by equipment and controls vendors' factory-trained personnel. Owner shall determine which systems require additional instruction. Duration of training shall vary based on the piece of equipment that

will be accepted by Owner. Duration of instructions for controls shall take the equipment through a complete cycle of operation (at least five working days). Make adjustments under operating conditions.

C. Provide electronic Operation and Maintenance Manuals at the completion of the project. Contractor shall obtain, at time of purchase of equipment, electronically formatted versions of operation, lubrication, and maintenance manuals for all items. Contractor shall assemble this literature along with other information in coordinated electronic manuals with additional information describing combined operation of field assembled units, including as-built wiring diagrams.

D. Provide a list containing names and addresses of manufacturers and local representatives who stock or furnish repair parts for items or equipment.

E. Divide manuals into three sections or books as follows:
   1. Engineering flow diagrams and controls sequences from project plumbing drawings, approved automatic temperature controls submittal, equipment startup procedures and operational instructions. Startup and operational instructions shall list valves, switches, and other devices used to start, stop, and control systems. Describe procedures to be followed in case of malfunctions. Include approved valve directory showing each valve number, location of each valve, and equipment or fixture controlled by the valve.
   2. Detailed maintenance and troubleshooting manuals containing data furnished by the manufacturer for complete maintenance. Include a copy of the balancing report.
   3. Lubrication instructions detailing the type of lubricant, amount, and intervals recommended by the manufacturer for each item of equipment. Include additional instructions necessary for the implementation of a first-class lubrication program. Where appropriate, include an approved summary of the lubrication instructions in a chart form.

F. Submit an electronic format version of the manual(s) to the Architect for approval. After approval, submit electronic version and one hard copy for the Architect’s distribution to the Owner. Deliver manuals no less than 30 days prior to acceptance of the equipment to permit the Owner's personnel to become familiar with the equipment and operation prior to acceptance.

1.8 SUBSTITUTIONS

A. Submittal of substitute equipment performance data shall be made in strict adherence to the requirements set forth in Division 01 General Requirements, Supplemental General Requirements and in Instructions to Bidders.

1.9 SEQUENCING AND SCHEDULING

A. Coordinate mechanical equipment installation with other building components.

B. Arrange for openings in building structure during progress of construction to allow for mechanical installations.

C. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work.

D. Coordinate requirements for access panels and doors if mechanical items requiring access are concealed behind finished surfaces.

1.10 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel." and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

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. Furnish and install necessary equipment and materials required to provide a complete HVAC system as shown on the Drawings.

D. System shall be in place tested (as specified), inspected and approved by all authorities having jurisdiction (where applicable).

E. Materials furnished and installations made under this specification shall conform with applicable requirements of the codes, regulations and standards described herein, unless specifically described otherwise.

F. If any codes, standards, or regulations conflict, the most stringent shall apply.

G. Systems shall comply with the latest version and associated references standards of the following codes:
   1. Code compliance: all work shall comply with or surpass the requirements of the New York State codes and reference standards. Conform to applicable code for the work described within the contraction documents.
   2. Systems shall comply with the latest version and associated references standards of the following codes:
      a. 2020 Building Code of New York State
      b. 2020 Energy Conservation Construction Code of New York State
      c. 2020 Existing Building Code of New York State
      d. 2020 Fire Code of New York State
      e. 2020 Fuel Code of New York State
      f. 2020 Plumbing Code of New York State
      g. 2020 Mechanical Code of New York State
      h. 2020 Property Maintenance Code of New York State

3. All work shall meet the requirements of the afore mentioned codes and all codes and standards referenced in the specifications. Although the details of such work may not be shown on the drawings or referenced in the specifications
4. Conflicts between the applicable codes, standards, and the plans and specifications must be brought to the attention of the engineer prior to proceeding with the work in question.
5. Conflicting standards: in case of conflict between the contract documents and a governing code or ordinance, the more stringent standard shall apply.

H. Materials and equipment installations shall comply with standards of:
1. National Fire Protection Agency (NFPA).
2. Local Utilities.
3. Owner's Insurance Underwriters.
4. Applicable Government Agencies and Departments.
5. Underwriters Laboratory (UL).
6. Federal and State Occupational Safety and Health Act (OSHA).
7. Local Municipality.
8. Local Fire Department.
9. American Gas Association (AGA).
10. ANSI - American National Standards Institute.
11. ASTM Regulations and Standards for pipe, fittings, pressure vessels, testing and insulation.
12. Conformance with the applicable codes, rules, and regulations of the State of New York, NYCRR, Code Rule 4 and Code Rule 14, pertaining to boilers, gas and oil burners, controls, and protective devices.
13. AWWA American Water Works Association.
14. Electrically powered equipment shall comply with the National Electric Code (NEC) and shall be UL listed for the intended usage

I. Interpretations
1. The Engineer shall provide advisory interpretations to the code regulations as requested by the contractor during construction.
2. The Department of State are the “Authorities having Jurisdiction” Construction must comply with their requirements. Work discovered not to be incompliance to the Authorities interpretation of the code regulations shall be corrected by the contractor at no additional cost to the owner.
3. The Department of State code interpretations and construction requirements shall supersede that of the Engineer.

J. Manufacturer qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

K. Approved Manufacturers:
1. A listed approved manufacturer does not relieve or relax any specification requirements.
2. Manufactures listed in the specifications and/or under addendum still must fully comply with the technical description as described in the project documents.
3. Inferior manufacturers standard offerings of products will not be accepted in lieu of the specified product.
4. The Architect/Engineer shall make the final judgment in determining if a product meets the full intent of the specifications.

a.

1.11 CONNECTIONS

A. Furnish and install utilities serving equipment which is to be furnished by others in accordance with the sizes and locations shown on the drawings complete with final connections including provisions for shut-off and adapters as required.

B. Furnish and install required ductwork and fittings for connection of new grilles. Furnish and install balance dampers as noted or specified.

C. Provide isolation valves at each unit.

1.12 STRUCTURAL SUPPORTS

A. Furnish and install brackets and/or supports for the mechanical installations in excess of building structure as shown on drawings. Where detail is not shown, submit shop drawings of intended construction for approval.

1.13 DELIVERY, STORAGE, AND HANDLING

A. 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.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

D. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.14 COORDINATION

A. Layout of equipment, piping, ductwork, etc. is diagrammatic. Check project drawings prior to making installations for interferences with other trades. Should the contractor find such interferences, he shall be responsible for coordinating his work with the other responsible trades. Owner reserves the right to make reasonable changes prior to "roughing-in" without added expense. Dimensions shown are subject to verification of exact site conditions.

B. Refer to reflected ceiling plans, structural drawings and architectural drawings and coordinate fire protection, Plumbing. HVAC and Electrical installations with ceiling patterns, lighting layouts, building structural members, etc. Coordinate the fire protection installations with the work of others engaged in the installation to preclude the possibility of interference with fire protection installations shown on the drawings.

C. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

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

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

F. Equipment configuration and layout has been developed on the 'BASIS OF DESIGN EQUIPMENT' noted in the equipment schedules. Final placement and layout of the equipment in the mechanical rooms shall be coordinated by the contractor based on the approved submittals to achieve recommended equipment clearances as required by the equipment manufacturer and maintenance clearances. The contractor shall be required to develop equipment room coordination plans noting the location of the equipment, piping, and other major components in the mechanical room prior to installation. Coordination drawings shall be submitted for approval.

G. All systems serving other areas of owner-occupied facilities shall remain fully active at all times. System shutdowns shall be coordinated with owner field representative as required to accomplish system tie in, system extension and/or system removal work.

H. All work on existing systems that are to remain active during construction shall be accomplished as coordinated with owner field representative.

I. Systems serving other areas of the owner-occupied facilities shall remain active at all times.

J. If a system serving the owner-occupied area is interrupted or made nonfunctional due to this project construction activity, the contractor disabling the service shall provide temporary services as required to keep owner operations fully functional within owner occupied facility.

K. System shutdowns shall be coordinated with owner field representative as required to accomplish system tie in, system extension and/or system removal work.

L. Duct detectors shall be furnished per Division 26, installed per Division 23, and wired per Division 26.

1.15 PROJECT CONDITIONS

A. Contract Drawings are in part diagrammatic, intended to convey to the Contractor for the Electrical Work, the scope of work and indicate general arrangement of equipment and outlets. Follow these drawings in laying out the work. Verify spaces in which the work will be installed.

B. Verify location of existing utilities before proceeding with the work.

C. Proposed ductwork and ductwork connections to match existing materials being connected into unless noted otherwise.

D. Verify scope of work: Visit the job site prior to submitting a bid to ascertain existing field conditions and to determine the scope of the work, and to become familiar with the existing conditions that will affect his work and, therefore, the bid. Additional cost resulting from the contractor's failure to verify the scope of the work shall be the contractor's responsibility and shall be paid by the contractor.

E. Erect and maintain temporary partitions to prevent spread of dust, odors, and noise to permit continued owner occupancy throughout the building.

F. Work areas are to be kept free of debris at all times and are to be left broom clean at the end of each working day.

G. Adjacent areas are to be protected from dust and debris.

H. Do not close or obstruct egress width to any building or site exit.

I. Obtain and pay for required permits from authorities.

J. Conform to applicable code for the work described within the construction documents. Base bid amount shall include additional work required by the authorities having jurisdiction pertaining to the completion of this project.

K. Contractors shall follow owner's safety requirements during construction.

L. Conform to owner's safety procedures if hazardous or contaminated materials are discovered.

M. The owner shall direct the contractor where to store salvaged items, equipment and materials removed from the work area.

N. The owner shall direct the contractor where construction materials, furniture and equipment to be installed shall be staged and stockpiled during construction.

O. The work specified herein and indicated on drawings shall be completed, tested and made ready for operation prior to turn over to the owner. Unless specifically indicated, materials and equipment shall be new and first-class quality.

P. Follow owner's safety requirements during construction.

Q. Obtain and pay for required permits from authorities.

R. Refrigerant reclamation is required for the removal of equipment noted in the contract documents that contain refrigerant prior to disposal.

1.16 SYSTEMS

A. The contractor shall be responsible to provide complete and operable systems, including operational properties to the extent necessary to link multiple components of a system together and to interface with other systems.

1.17 BASIS OF DESIGN EQUIPMENT

A. Drawings equipment schedules. Add the following general note.
   1. Manufacturer and Model number of equipment included in schedule is the basis of design for project.
   2. Adjustment shall be made by the contractor for equipment other than the bases of design to comply the installed equipment manufacturer's requirements.

B. Project Manual Add the following general note.
   1. Manufacturer and Model number of equipment included in specifications is the basis of design for project.
   2. Adjustment shall be made by the contractor for equipment other than the bases of design to comply the installed equipment manufacturer's requirements.

1.18 SALVAGED ITEMS

A. Remove all unused existing equipment where accessible and offer all salvage material to the owner.

B. Owner shall have first right of refusal of all salvageable materials removed from the building.

C. Materials not claimed by the owner shall become the property of the contractor.

D. Dispose of all material not retained by the owner in a lawful and legal manner away from the site.

E. Items salvaged shall be moved and stored in a location as directed by the owner.

F. The owner shall direct the contractor where to store salvaged items, equipment and materials removed from the work area.

G. At the start of the project, the Owner and contractor shall survey the building and identify all items to be salvaged and turned over to the owner

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials and equipment shall be in strict accordance with the parameters hereinafter specified and as shown on the drawings.

B. Materials and equipment furnished/provided shall be new unless noted otherwise.

C. Flanges shall be of U.S. or Canadian manufacturer only.

2.2 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/16-inch maximum thickness unless thickness or specific material is indicated.

C. Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated

2.3 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

B. Sealing Elements: NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. Pressure Plates: Carbon steel. Include two for each sealing element.

D. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.4 ACCESSORIES

A. It is the intent of this specification that systems and equipment shall be complete with all accessories required to insure a complete system.

2.5 ELECTRICAL CONNECTIONS

A. The contractor for HVAC/Mechanical equipment shall provide required motor disconnects, starters and variable frequency controllers for equipment motors unless specified and noted elsewhere.

B. Unless noted otherwise in the construction documents, it is the HVAC/Mechanical contractors' responsibility to coordinate with the Electrical Contractor to determine what components are to be provided by each contractor.

C. Electrical components provided shall be in compliances and sized in accordance with the National Electrical Code NFPA 70.

D. Electrical equipment shall be UL listed

2.6 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

2.7 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
   2. Basis of Design: Subject to compliance with requirements, provide products by the manufacturers specified.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

A. Refer to specification Sections for "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
   1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
   3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
   4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
   5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.

C. REMOVE all abandoned housekeeping pads for equipment that is no longer in service and has been removed. All floor mounted equipment shown to be removed is on a housekeeping pad that will need to be removed. Repair floors to match existing. (Not all pads shown on the documents)

D. The layout of system, equipment etc. is diagrammatic in nature. Not all components are shown on the drawings.

E. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

F. Contractor shall notify the owner in advance of any shutdown necessary of the existing systems. Minimum notification time shall be 72 hours.

G. Do not disable or disrupt building systems without 3 days prior written notice to owner.

H. Provide temporary services to maintain existing systems in service during construction.

I. Refrigerant reclamation is required for the removal of equipment noted in the contract documents prior to disposal. Refrigerant reclaim shall be completed before Abatement Contractor removal of water cooler and other equipment with refrigerant circuits.

J. Abandoned and inactive components shall be removed back to their active main or area and terminated.

K. All demolished equipment is to be considered the property of the Owner

L. IF the Owner does not wish to retain the equipment, the contractor will be responsible for disposal as part of this specification. Verify status with the Director's Representative.

3.2 CUTTING AND PATCHING

A. The contractor shall be responsible for cutting and patching as described herein or as indicated on the drawings. The contractor shall be responsible for coordinating his cutting and patching requirements with the other trades.

B. Connection of new services to existing shall be in a neat and approved manner with disturbed services restored to original condition.

C. Do cutting and patching work as noted and as necessary for the installation of the fire protection work.

D. Cut, channel, chase, and drill ceilings, and other surfaces necessary for fire protection installations. Perform cutting by skilled mechanics of trade involved.

E. Repair cut surfaces to match adjacent surfaces.

F. The contractor is responsible for cutting and patching of existing work to facilitate and to conceal the work described within these documents. Surfaces to be patched shall be finished to match the existing surface. Owner has final say as to the acceptability of the finished patched work.

G. Core drill openings in concrete floors necessary for Fire Protection Systems

3.3 INSTALLATION

A. Unless otherwise noted or specified, materials and equipment shall be installed in strict accordance with the manufacturer's instructions and recommendations.

B. Do not scale Drawings.

C. The location of new piping and ductwork is approximate. The exact location of piping and ductwork shall be determined in the field to:
   1. Provide manufacturer's recommended clearances.
   2. Avoid interference with existing conditions.
   3. Avoid interference with new work of other trades.

D. Provide additional fittings as required to effect required changes in slope, direction and elevation without added expense.

E. Provide additional offsets and fittings as required to accommodate obstructions that are to remain.

F. Do not cut any structural building member without permission of the Architect.

G. Provide duct detectors for air handlers with return air volumes equal to or greater than 2,000 CFM. Duct detector shall be installed in the return ductwork prior to the air handler. **The duct detectors shall be wired back to the air handler starter and the building fire alarm main panel.** Coordinate with the Fire Alarm System
   1. Upon activation of the fire alarm panel,
      a. The air handler shall be shut down by the building fire alarm panel.
      b. The Fire Alarm panel shall be notified the Building Management System BMS.
      c. The BMS may shutdown other air handlers based on BMS programming.

H. Provide interlocking controls for air handlers with the building fire alarm system. Upon activation of the building Fire Alarm system, the fans within the air handlers shall be shut down. Coordinate installation with the manufacture of the building fire alarm system and Building Management System BMS.
   1. The BMS is not a life safety system. All life safety shutdowns shall be initiated by the fire alarm panel.
   2. Duct Detectors that control smoke dampers or Fire/Smoke dampers shall close the designated damper and single the fire alarm system. The FAP shall shutdown the related AHU and single the BMS

I. Provide volume dampers within the ductwork prior to air terminal devices to include but not limited to the following**, supply grilles, supply diffusers, return grilles, exhaust grilles.**

J. The actual relative locations of piping, equipment, etc. shall be adjusted during construction according to final placement of equipment.

K. Provide required offset, transitions, fittings, and components etc. as required to complete the installation of the systems in order to conform to the building structure and existing building systems. This shall include but not be limited to piping systems, duct systems, etc.

L. Systems serving other areas of owner facilities shall remain active and fully functional throughout the duration of the project for Owner occupied areas. System shutdowns shall be coordinated with owner's field representative as required to accomplish system tie in, system extension and/or system removal work.

M. Work on existing systems that are to remain active during construction shall be coordinated with owner's field representative.

N. Contractor is responsible for verification of all dimensions.

O. The layout of piping, equipment etc. is diagrammatic in nature. After field verification of actual site conditions, provide required offsets to accommodate obstructions and final system placement without added expense.

P. Protect remaining ductwork and duct insulation for ducts that are to remain from damage during construction.

Q. Repair damages to the existing ductwork and exterior duct insulation within the work area that is to remain.

R. Seal off return air grilles during construction.

S. Remove branch piping back to the risers and cap piping at the riser and label. Typical for all system types.

T. Remove branch ductwork back to the risers and cap ductwork at the riser and label. Typical for all system types.

U. Connect new ductwork to existing duct as indicated on the plans.

V. Remove existing branch duct, patch and seal airtight existing duct\work that is to remain.

W. Coordinate location of thermostat with light switches.

X. All exposed **ductwork shall be insulated with rigid duct board and wrapped with canvas jacket sized for painting.**

Y. Unless noted otherwise, system components shall not be exposed. Piping and ductwork shall be concealed within the ceilings and wall structures.

Z. Belt Driven Fans: Provide replacement fan sheaves and fan belts for fans that cannot be balanced within 10% of design volume with the factory installed sheaves and belts. Select sheaves to provide design volumes within the installed motor capability.

AA. Adjustable Sheaves: After fans have been balanced to the design flow rates, the adjustable sheave shall be replaced **with a fixed sheave to achieve the design airflows. Provide proper fan belts for the fixed sheaves.**

BB. The drawings do not show all offsets or fittings required for installation. Schematic diagrams convey the configuration and system components, but not all of the fittings required for the final installation are shown.

3.4 PROTECTION

A. All materials, equipment and accessories shall be suitably protected and covered during construction.

B. Damage responsibility: The contractor shall be responsible for any loss or damage caused by him or his workmen to the facility, building surfaces or equipment during the course of construction, and shall be fully responsible for repairing or replacing as required to insure restoration to original condition.

C. Damaged items: Where items scheduled for reuse are found to be in damaged condition, the contractor shall call the attention of the owner to such items and receive further instructions prior to removal. Items damaged during removal shall be repaired or replaced by the contractor at no additional cost to the owner.

D. Repair damages: Promptly repair damage to adjacent facilities by demolition operations at no cost to the owner.

3.5 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements 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 Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
   1. Piping can be exposed at the discretion of the Owner in areas included, but not limited to: locked mechanical rooms, locked equipment rooms and locked maintenance rooms.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors.

M. Install piping at right angles or parallel to building walls.

N. Install piping to permit valve servicing. Chain operated valves are not acceptable below 95” Install chainwheels on operators for gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

P. HTHW piping (Above 200 degrees F): All fitting shall be welded or flanged connections. Threaded connections are not allowed to be used for the HTHW system. Equipment and Valves shall have flanged connection within this system.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1. Install steel pipe for sleeves smaller than 6 inches in diameter.
   2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
   3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

S. Verify final equipment locations for roughing-in.

T. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

U. 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.

V. Install strainers with drains, consisting of a 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.

W. For all equipment install drains, consisting of a 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.

3.6 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. 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.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel, and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.

D. Install equipment to allow right of way for piping installed at required slope.

3.8 PEX TUBING

A. PEX Tubing shall not be allowed.

3.9 PAINTING AND FINISHING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

C. EXPOSED DUCTWORK: Verify that cutting oils and lubricants are removed from the ductwork prior to painting to prevent staining of the paint when dry. This includes washing the inside of spiral ductwork prior to hanging.

3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

D. Concrete Pads:
   1. Anchor Equipment to Concrete pads. Refer to the Mechanical Code of New York State section - M1004.4. Anchor Boilers, Chillers and Base Mounted Pumps to Concrete pads. Refer to ASCE 7-16 Chapter 13 for seismic requirements for building system in Risk Category IV and Design Category A.
      a. Mounting. Equipment and appliances shall be set or mounted on a level base capable of supporting and distributing the weight contained thereon.
      b. Boilers, tanks, equipment, and appliances shall be securely anchored to the structure. Equipment and appliances requiring vibration isolation shall be installed as designed by a registered design professional.
      c. Submit anchor details based on the actual equipment to be installed after receiving approved submittals.

3.11 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.12 TESTING

A. Piping shall be tested as required by the construction documents, The 2020 Mechanical Code of New York State and the 2020 Building Code of New York State.

B. Operating Tests
   1. The Contractor to demonstrate that all equipment and controls are working in accordance with design requirements by performing operational tests. Additionally, specifications shall be fully coordinated with the commissioning specifications relative to the mechanical contractor's roles and responsibilities.
      a. The Contract shall coordinate all sub contactors and manufacturing representatives to provide theses services. To the Owner
   2. The operational tests shall simulate normal system operation to confirm the systems function as designed.
   3. The operational tests shall be performed by the Contractor upon completion of system balancing.
   4. Tests shall be conducted in the presence of the Commissioning Authority and the Owner or Owner's representative.
   5. All deficiencies identified during operational tests shall be corrected by the Contractor. The systems shall be retested as necessary to confirm proper system operation.
   6. The contractor shall submit a final testing report to Commissioning Authority, Design Consultant and the Owner or Owner's representative.

C. Pipe Testing:
   1. Hydronic, and refrigerant piping shall be tested in accordance with the 2020 Fire Code of New York State, 2020 Mechanical Code of New York State, 2020 Building Code of New York State. Natural gas piping shall be tested in accordance with the 2020 Fire Code of New York State, 2020 Mechanical Code of New York State, 2020 Building Code of New York State. The pipe testing specifications shall address the following:
      a. Identification of the systems that must be tested.
      b. Test medium (air, water, etc.).
      c. Test pressure.
      d. Test duration.
      e. Required outcome for a successful test.
   2. Test reports shall be submitted to the Design Consultant for review before ductwork and piping systems are concealed in the building construction.

D. Air and Water System Testing and Balancing
   1. All air and water systems shall be balanced.
   2. The ventilation rate shall be measured for all system operating sequences and documented to confirm compliance with the 2020 Fire Code of New York State, 2020 Mechanical Code of New York State and 2020 Building Code of New York State.
   3. A balancing report shall be submitted to the Design Consultant for review and approval prior to the physical completion inspection.
   4. The balancing report shall be reviewed and when necessary returned to the balancing contractor for correction and subsequent resubmission.
   5. The Owner may retain an independent balancing contractor or a commissioning authority to spot check the balancing contractor's report. If more than a 10% error is found, the balancing contractor will be required to rebalance the entire system at no charge.

E. Air Systems

1. All supply return and exhaust mains shall be pressure tested in accordance with the latest edition of SMACNA HVAC Air Duct Leakage Test Manual for the pressure class specified. The consultant shall specify all testing requirements in compliance with the 2020 Fire Code of New York State, 2020 Mechanical Code of New York State and 2020 Building Code of New York State., notwithstanding SMACNA notes regarding pressure class 2" WC and less.

F. CHAPTER M10 - BOILERS, WATER HEATERS AND PRESSURE VESSELS
   1. In addition to FACTORY TESTING of assembled equipment.
   2. M1011 – TESTS
      a. **MC1011.1 Tests.** Upon completion of the assembly and installation of boilers and pressure vessels, acceptance tests shall be conducted in accordance with the requirements of the ASME *Boiler and Pressure Vessel Code* or the manufacturer's requirements, and such tests shall be approved. A copy of all test documents along with all manufacturer's data reports required by the ASME *Boiler and Pressure Vessel Code* shall be submitted to the *building official*.
      b. **MC1011.2 Test gauges.** An indicating test gauge shall be connected directly to the boiler or pressure vessel where it is visible to the operator throughout the duration of the test. The pressure gauge scale shall be graduated over a range of not less than one and one-

G. CHAPTER M11 - REFRIGERATION
   1. §M1108 - FIELD TEST
      a. §M1108.1 General. Every refrigerant-containing part of every system that is erected on the premises, except compressors, condensers, vessels, evaporators, safety devices, pressure gauges and control mechanisms that are listed and factory tested, shall be tested and proved tight after complete installation, and before operation. Tests shall include both the high-and low-pressure sides of each system at not less than the lower of the design pressures or the setting of the pressure relief device(s). The design pressures for testing shall be those listed on the condensing unit, compressor or compressor unit nameplate, as required by ASHRAE 15.
         1) Exceptions:
            a) Gas bulk storage tanks that are not permanently connected to a refrigeration system.
            b) Systems erected on the premises with copper tubing not exceeding 5/8-inch (15.8 mm) OD, with wall thickness as required by ASHRAE 15, shall be tested in accordance with §M1108.1, or by means of refrigerant charged into the system at the saturated vapor pressure of the refrigerant at 70 deg F (21 deg C) or higher.
            c) Limited-charge systems equipped with a pressure relief device, erected on the premises, shall be tested at a pressure not less than one and one-half times the pressure setting of the relief device. If the equipment or appliance has been tested by the manufacturer at one and one-half times the design pressure, the test after erection on the premises shall be conducted at the design pressure.
      b. §M1108.1.1 Booster compressor. Where a compressor is used as a booster to obtain an intermediate pressure and discharges into the suction side of another compressor, the booster compressor shall be considered a part of the low side, provided that it is protected by a pressure relief device.

c. §M1108.1.2 Centrifugal/nonpositive displacement compressors. In field-testing systems using centrifugal or other nonpositive displacement compressors, the entire system shall be considered as the low-side pressure for field test purposes.
d. §M1108.2 Test gases. Tests shall be performed with an inert dried gas including, but not limited to, nitrogen and carbon dioxide. Oxygen, air, combustible gases and mixtures containing such gases shall not be used.
1) Exception: The use of air is allowed to test R-717, ammonia, systems provided that they are subsequently evacuated before charging with refrigerant.
e. §M1108.3 Test apparatus. The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device and a gauge on the outlet side.
f. §M1108.4 Declaration. A certificate of test shall be provided for all systems containing 55 pounds (25 kg) or more of refrigerant. The certificate shall give the name of the refrigerant and the field test pressure applied to the high side and the low side of the system. The certification of test shall be signed by the installer and shall be made part of the public record.

2. §M1109 [F] - PERIODIC TESTING
a. §M1109.1 Testing required. The following emergency devices and systems shall be periodically tested in accordance with the manufacturer's instructions and as required by the code enforcement official:
1) Treatment and flaring systems.
2) Valves and appurtenances necessary to the operation of emergency refrigeration control boxes.
3) Fans and associated equipment intended to operate emergency pure ventilation systems.
4) Detection and alarm systems.

H. CHAPTER M12 - HYDRONIC PIPING
1. §M1208 - TESTS
a. §M1208.1 General. Hydronic piping systems shall be tested hydrostatically at one- and one-half times the maximum system design pressure, but not less than 100 psi (689 kPa). The duration of each test shall be not less than 15 minutes.
b. High Temperature (HTHW) piping systems shall be tested hydrostatically at one and one half times the maximum system design pressure, but not less than 600 psi. (600 psi minimum or 1.5 times maximum operating pressure over 400 Psi) The Duration of each test shall be not less than 15 minutes.

3.13 STARTING OF EQUIPMENT AND SYSTEMS

A. Coordinate schedule for start-up of various equipment and systems.

B. Notify Engineer seven days prior to start-up of each item.

C. Prior to starting equipment or systems.
1. Verify that wiring and support components for equipment and systems are complete and tested.
2. Verify tests, meter readings, and specified electrical characteristics agree with those required by the equipment manufacturer or system supplier.

3. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, electrical phasing, motor rotation and for other conditions which may cause damage if equipment or systems are operated.

D. Execute start-up in accordance with manufacturer's instructions under supervision of applicable manufacturer's representative or Contractor's qualified personnel.

E. When specified in individual specification Sections, require manufacturer to provide authorized representative at site for startup services. Representative shall inspect, check, and approve equipment and/or system installation prior to start-up, and shall supervise placing equipment or system in operation. Representative's services shall be in accordance with Section 014000 and the individual Sections and shall include a written report indicating that the equipment or system has been properly installed and is functioning correctly.

F. In addition to manufacturer's field services specifically required by the Contract Documents, Contractor shall provide, at Contractor's expense, such additional manufacturer's field services as are needed to assure proper installation and startup.

3.14 TESTING, ADJUSTING AND BALANCING

A. Test, adjust and balance equipment and systems to achieve the specified performance. When required in individual Sections, Contractor shall employ and pay for services of manufacturer's representative or an independent firm to provide testing, adjusting and balancing. Factory balanced motors shall be rebalanced after installation to confirm balance within factory tolerances.

B. In addition to services of manufacturer's representatives or independent firms specifically required by the Contract Documents, Contractor shall provide, at Contractor's expense, such additional services as are needed to assure proper testing, adjusting and balancing.

C. All testing, adjusting and balancing shall be scheduled with Engineer at least 7 days in advance.

D. Reports shall be submitted to Engineer indicating observations and results of tests and performance, both before and after adjustment and balancing, and shall specifically indicate compliance or non-compliance with the requirements of the Contract Documents.

E. Fan: Fan Sheaves and belts shall be adjusted as required to achieve the design flows. Contractor shall replace fan sheaves and belts without overloading the fan motor to achieve the design flows.

F. Contractor shall:
1. Test all systems and equipment to assure proper operation, and to comply with applicable codes and standards.
2. Pretest all systems before notification to the Owner or the Owner's Representative for observation of final testing.
3. Notification shall be in writing to allow sufficient time for witnessing by Owner or the Owner's Representative.

4. Provide required testing apparatus to properly test all systems.
5. Schedule testing to avoid delays and to expedite progress of the work.
6. Correct all damage caused by or during the testing at no additional cost.

3.15 DEMONSTRATION AND TRAINING

A. Demonstrate operation and maintenance of Equipment and systems to OWNER personnel and provide all required training prior to date of Partial Utilization or Substantial Completion.

B. Training shall be scheduled at least fourteen days in advance. Contractor shall provide on-site training classes for Owner personnel on the proper operation and maintenance of all new equipment provided as a part of this Contract.

C. Demonstrate all equipment and systems and train Owner personnel in a room located at the site along with hands-on training in the field. Demonstration and training is to be provided by representatives of the Contractor and/or manufacturers who are qualified and knowledgeable about the equipment and systems and their operation and maintenance specifically for this Project. When specifically required in the individual specification Sections, manufacturer's representatives must be used for this demonstration and training. Refer to Section 01 4000 regarding manufacturer's field services and reports.

D. For equipment or systems requiring seasonal changes in operation, perform demonstrations for other seasons as soon as appropriate conditions for such demonstrations exist, in the opinion of the Engineer.

E. Demonstrate start-up, operation, control, adjustment, troubleshooting, servicing, maintenance and shutdown of each item of equipment and each system.

F. Utilize operation and maintenance data as basis for training. Review data with Owner personnel in detail to explain all aspects of operation and maintenance.

G. Prepare and insert additional data in operations and maintenance manuals when need becomes apparent during demonstration and training.

H. The amount of time for demonstration and training on each item of equipment and system shall be that required to fully demonstrate the item or system, to cover all topics in the approved training outline or lesson plan and to answer questions raised by Owner personnel. When specific durations are identified in the individual Sections, those durations shall be considered minimums.

I. The Owner staff may video tape all demonstrations and training sessions, to be utilized as future training tapes.

J. Minimum Training requirements noted in technical sections include but not limited to the individual trade sections.

3.16 ORIENTATION INSTRUCTION

A. Contractor shall provide the services of qualified persons to demonstrate the operation of installed equipment and apparatus.

B. Advance notice of not less than 48 hours should be given to the Owner or the Owner's Representative prior to scheduling the demonstration. No equipment or apparatus will be accepted until demonstration has been performed and accepted.

3.17 PROJECT CLOSE OUT INSPECTIONS

A. General: In order to ensure that all Contract requirements are met and that the work is complete and acceptable, the following inspections will be made in addition to the normal daily inspections. The purpose of these inspections is to furnish Contractor, in writing, lists of Contract exceptions, omissions and incompletion in order to reach Contract completion in an expeditious and satisfactory manner and to establish a physical completion date.
   1. Punch List Inspection: Will be made when the work is reasonably complete as determined by the Engineer and/or the Designed Representative. A copy of the detailed inspection list will be furnished to the Contractor and when this inspection progresses over any length of time, copies of the list will be furnished as the inspection progresses so that the Contractor may proceed with the required work without delay.
   2. Physical Completion Inspection: When Contractor considers that the Work or a designated portion is acceptable to the Owner as substantially complete, the Contractor shall submit to the Architect, Engineer and Owner or the Owner's Representative a list of items to be completed or corrected. The failure to include any items on such list does not alter the responsibility of the Contractor to complete all Work in accordance with the Contract Documents.
   3. Final Completion Inspection:
      a. The Contractor shall advise the Architect, Engineer and the Owner or the Owner's Representative in writing when all work designated as incomplete during the Physical Completion Inspection has been completed.
      b. All Change Order work must be identified. The Contractor must have approval by Estimating of all Change Order Proposals 2 weeks before the final inspection.
      c. The Corporation will establish a date and time for a final inspection which will be conducted by representatives of the Corporation, the Institution, the Architect, Engineer and the Contractor. Only one final inspection will be made.
      d. Providing all work is complete and acceptable including approval of the Office of State Comptroller of all Change Orders, the contractor will be directed to submit its final application for payment together with all other required documentation and submittals.

3.18 CEILING SYSTEM NOTES

A. Plaster frames shall be provided for air terminal equipment and access doors installed in plaster or gypsum board ceiling.

B. Lay-in frames shall be compatible with the ceiling grid system. Note where standard and micro-grid ceiling systems are to be installed throughout the project area. Coordinate equipment frames accordingly.

3.19 MOTOR EFFICIENCIES

A. The efficiencies of motors shall meet or exceed those listed in Table 1, NEMA Premium Efficiency Levels. Refer to section 230513 Common Motor Requirements (verify section was included)

	Minimal Nominal Full Load Efficiency (%)					
	4 POLE		6 POLE		8 POLE	
No. of Poles	ENCLOSED	OPEN	ENCLOSED	OPEN	ENCLOSED	OPEN
Motor HP.						
1	85.5	85.5	82.5	82.5	77.5	77.5
1 1/2	86.5	86.5	87.5	86.5	78.5	77.0
2	86.5	86.5	88.5	87.5	84.0	86.5
3	89.5	89.5	89.5	88.5	85.5	87.5
5	89.5	89.5	89.5	89.5	86.5	88.8
7 1/2	91.7	91.0	91.0	92.0	86.5	89.5
10	91.7	91.7	91.0	91.7	89.5	90.2
15	92.4	93.0	91.7	91.7	86.5	90.2
20	93.0	93.0	91.7	92.4	90.2	91.0
25	93.6	93.6	93.0	93.0	90.2	91.0
30	93.6	94.1	93.0	93.6	91.7	91.7
40	94.1	94.1	94.1	94.1	91.7	91.7
50	94.5	94.5	94.1	94.1	92.4	92.4
60	95.0	95.0	94.5	94.5	92.4	93.0
75	95.4	95.0	94.5	94.5	93.6	94.1
100	95.4	95.4	95.0	95.0	93.6	94.1
125	95.4	95.4	95.0	95.0	94.1	94.1
150	95.8	95.8	95.8	954.0	94.1	94.1
200	96.2	95.8	95.8	95.4	94.5	94.1

3.20 FIRE PROTECTION

A. Fire rated assemblies: Provide fire retardant NRTL approved sealant on raceway penetrations of fire rated ceilings, partitions, walls, and structural slabs. It shall be the responsibility of the Contractor to verify locations of such fire rated partitions, walls and structural slabs prior to submitting bid.

B. Fire rated assemblies: Fire rated assemblies to be penetrated shall be installed with applicable through-penetration fire-stop system determined by U.L. classification.

C. Fire alarm system modification shall be coordinated with central security before making any alterations.

3.21 ACCESS DOORS – FINISHED SURFACES

A. Coordinate with other trades to provide wall, ceiling or floor access doors at locations where equipment, data and cable raceways, j-boxes, and other components needing access that are located within concealed spaces. Typical for walls, floor and ceilings.

B. Coordinate with other trades to provide wall, ceiling or floor access doors where equipment and raceways are not exposed. Doors shall be flushed mounted with key lock, with full piano hinge sized to adequately access components and raceways.

C. Provide wall, ceiling, or floor access doors at locations where equipment, valves, j-boxes, controls, fire dampers, control dampers, and other components needing access that are located within concealed spaces that require access per code or maintenance. Typical for walls, floor, and ceilings.

D. Provide wall, ceiling, or floor access doors where valves and fittings are not exposed.

E. Access doors shall be flushed mounted with key lock to Owners keying system, with full piano hinge sized to adequately access components and not smaller than 18”x18” Wall 24”x24” Ceiling.

F. Access doors for high-risk areas shall be as per Division 8 high security access doors.

G. All access doors shall have tamper proof fasteners.

H. Doors shall be polished stainless steel finished unless noted otherwise

I. Access doors shall be rated for the assembly they are to be installed in.

J. Refer to Division 8 specifications for additional information.

3.22 ADA WALL MOUNTING HEIGHT

A. Wall mounted components that require adjustment or manual operation shall be mounted so the top of the unit is 40” above the finish floor or below.

B. Wall mounted sensors that do not require adjustment or manual operations shall be mounted so the top of the unit is 54” above the finish floor or below.

3.23 DDC CONTROLS

A. Furnish all software and hardware components to the owner which are necessary for configuration and commissioning of all control hardware, with licensing to the owner for a period of at least one (1) year from date of substantial completion of the project. Since most BACnet controllers still require some sort of proprietary software for loading custom program logic, it is important that the owner have this software should their relationship with the vendor decline.

B. All custom programmable controllers (AKA, BACnet Advanced Application Specific Controllers, B-ASC) shall be capable of reading and writing to any BACnet object/property

combination on their network, be it a standard object/property or a proprietary object/property. This holds true for BACnet IP, BACnet MS/TP, and BACnet ARCnet networks. B-ASC controllers must be full "peer-to-peer" devices.

C. All B-ASC controllers shall implement the BACnet priority array method of controlling the state of analog outputs and binary outputs, to allow for operation of outputs by other systems according to the standard BACnet level 1-16 hierarchy.

D. If the manufacturer uses any non-standard objects or properties for any BACnet hardware devices, the PICS (Protocol Implementation Conformance Statement) document for the device shall include a full list of objects and properties with their object and property ID #'s. Any field defined objects and properties shall also be documented and attached to the PICS document(s).

E. All BACnet MS/TP or BACnet ARCnet to BACnet IP routing devices (i.e. a BACnet Building Controller, B-BC) shall offer "plug-and-play" auto discovery of standard BACnet objects and properties from the MSTP or ARCnet network onto IP. The routing device shall be capable of discovering proprietary objects and properties from the MSTP or ARCnet controller through a field definable means.

F. All BACnet Operator Workstation (B-OWS) software shall also offer the ability to auto discover standard BACnet objects and properties through the BACnet IP network, including tunneling through BACnet routers to discover BACnet MSTP and BACnet ARCnet objects and properties. The B-OWS shall be capable of discovering proprietary objects and properties through a field definable means.

3.24 INSPECTIONS

A. The Contractor shall have:
   1. Boilers to be inspected by a NYS certified Boiler Inspector.
   2. New York Board of Fire Underwriters inspect completed installation and present Owner with certificate of inspection showing approval.
   3. Required local or municipal inspection processed and present Owner with certificate indicating approval of such governing bodies.

3.25 OWNER TRAINING

A. Conduct training sessions to familiarize facility staff with the features, operation, and maintenance of the new system.

B. Training shall be a minimum of two 8-hour sessions.

C. Repeat training session quarterly for the duration of the Warranty Period.

END OF SECTION 230500

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SECTION 230513 - 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 2020 NYSECC: C403.8, C403.9, C405.7, where applicable.

C. All motors should abide by ASHRAE 90.1 full load efficiency ratings found in Section 10.

D. 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.

C. Motors Requirements
1. All motors shall have a 1.15 service factor.
2. All motors shall be premium efficiency and shall have their efficiencies determined in accordance with IEEE Standard 112 Method B.
3. Motors used with variable speed drives shall be inverter duty rated and compatible with the drive to which it is connected.
4. Variable speed or two-speed motors shall be provided where the driven equipment will be operating at part load and operating energy savings can be achieved.
5. Provide electronically commutated motors (ECM) for fractional hp motors to 10 hp or greater.

D. 208V/230V motors shall be used only when the manufacturer guarantees full load horsepower and full-service factor at the lower voltage without adverse effects on motor life, performance, or temperature rise

2.3 MOTOR STARTERS

A. In general, the starters for refrigeration equipment (e.g., water chillers, condensing units, etc.) shall be furnished by unit manufacturer.

B. The use of reduced voltage starting methods shall be considered for the following:
1. For motors over 20 Hp.
2. When the mechanical system is sensitive to high starting torque or jogs.
3. When the electrical system will be subjected to an excessive voltage drop upon starting of the motor.

2.4 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.

2.5 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 with 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. Grounding rings: Provide shaft grounding rings to divert harmful shaft voltages to ground to extend bearing life.
5. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.6 SINGLE-PHASE MOTORS

A. 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.

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

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

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

E. 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.

2.7 ELECTRONICALLY COMMUTATED MOTOR (ECM)

A. Provide AHUs, Fans, and other equipment with ECM as scheduled.
   1. Synchronous, constant torque, ECM with permanent magnet rotor. Rotor magnets to be time-stable, nontoxic ceramic magnets (Sr-Fe).
   2. Driven by a voltage converter with an integrated power factor correction filter. Conventional induction motors will not be acceptable.
   3. Each motor with an integrated speed controller, 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 equipment against over-/undervoltage, overtemperature of motor and/or electronics, overcurrent, locked rotor, and dry run (no-load condition).

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230516 - 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. Flexible-hose 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.
1. Submittal: For each anchor and alignment guide, including analysis data, by the qualified engineer responsible for their preparation.
2. Design Calculations shall be provided by the manufacturer for each application: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
3. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
4. Alignment Guide Details: Detail field assembly and attachment to building structure.
5. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
6. The locations of all expansion loops, compensators, guides, and anchors shall be shown on the floor plans shop drawings. Loops shall be drawn to scale to confirm there is sufficient space for installation.
7. Welding certificates.

1.4 CLOSEOUT SUBMITTALS

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

1.5 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.

2.2 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Packless Expansion Joints :
1. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
2. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
3. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with threaded end connections.
   a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
   b. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.
4. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with flanged end connections.
   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.
   b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.
5. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.
   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
   b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psigat600 deg F ratings.
6. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with flanged end connections.
   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145psig at 600 deg F ratings.
   b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.

2.3 GROOVED-JOINT EXPANSION JOINTS

A. For chilled water and condenser water systems only.

1. Not Approved for Hot Water system

B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

C. Standard: AWWA C606, for grooved joints.

D. Nipples: Galvanized, ASTM A53/A53M, Schedule 40, Type E or S, steel pipe with grooved ends.

E. Couplings: Seven, flexible type for steel-pipe dimensions. Include ferrous housing sections, ethylene-propylene-diene terpolymer rubber gasket suitable for cold water, and bolts and nuts.

F. Locations where grooved fittings can be used.
1. May be used for Make-Up Water, Chilled water, and Condenser water
2. Grooved fittings shall be accessible spaces only and not located in concealed spaces or be concealed.

2.4 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:
1. 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 GENERAL

A. Wherever possible, pipe bends, pipe offsets, swing connections or changes in direction shall be used. If the piping system cannot be employed to accommodate the expansion and contraction, expansion compensators shall be used.

B. Expansion compensators shall be a pre-manufactured assembly and shall have the same temperature and pressure rating as the system in which it is being installed.

C. Provide access doors for all expansion compensators and joints concealed in the building construction. The Design Consultant shall coordinate with the Architect regarding the locations of all anchors and the method of attachment to the structure.

3.2 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 grooved-joint expansion joints to grooved-end steel piping.

3.3 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.

3.4 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

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

B. Install **two** 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 230516

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SECTION 230517 - 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. Grout.
   5. Silicone sealants.

B. Related Requirements:
   1. Section 078400 "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.

PART 2 - PRODUCTS

2.1 SLEEVES

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. 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, 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.

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. Jay R. Smith Mfg Co; a division of Morris Group International.
2. Zurn Industries, LLC.

B. Description: Manufactured, galvanized 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. Proco Products, Inc.

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: Carbon steel.
5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B633 of length required to secure pressure plates to sealing elements.

2.4 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.

2.5 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Pecora Corporation.
      b. Polymeric Systems, Inc.
      c. Sherwin-Williams Company (The).
      d. The Dow Chemical Company.
   2. Verify sealant has a VOC content of **250** g/L or less.
   3. Verify sealant 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."

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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. May National Associates, Inc.; a subsidiary of Sika Corporation.
   2. Verify sealant has a VOC content of 250 g/L or less.
   3. Verify sealant 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."

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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Smooth-On.
   2. Verify sealant has a VOC content of **250** g/L or less.
   3. Verify sealant 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 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. 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.
   2. 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.

E. Provide sleeves for pipe penetrations through walls, floors, and partitions.

F. Core drilling should be avoided in all new construction. Sleeves for piping shall be set prior to the installation of the structure. Where core drilling is unavoidable or required by renovation projects, the locations of the cores shall be submitted to the Design Consultant for review.

G. Sleeves installed in rated construction shall be in accordance with the through penetration fire stop assembly listing.

H. In waterproofed floors, provide hard drawn Type L copper or galvanized steel sleeves and flashing collar of 6 lbs. sheet lead or 20 oz. copper, soldered to sleeve and extending 12" from sleeve. Sleeve shall extend a minimum of 2" above the floor and the annular space between the sleeve and the floor opening shall be sealed watertight with modular mechanical seal

I. 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 078400 "Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
   3. Install section of cast-iron soil pipe to extend sleeve to 3 inches above finished floor level.
   4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

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

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

C. In waterproofed floors, provide hard drawn Type L copper or galvanized steel sleeves and flashing collar of 6 lbs. sheet lead or 20 oz. copper, soldered to sleeve and extending 12" from sleeve. Sleeve shall extend a minimum of 2" above the floor and the annular space between the sleeve and the floor opening shall be sealed watertight with modular mechanical seal.

D. Sleeves installed in rated construction shall be in accordance with the through penetration fire stop assembly listing.

3.4 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.

3.5 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: Cast-iron sleeves, Steel pipe sleeves or Sleeve-seal fittings.
      b. Piping NPS 6 and Larger: Cast-iron pipe sleeves, Steel pipe sleeves or Sleeve-seal fittings.
   2. Exterior Concrete Walls Below Grade:
      a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system, Steel pipe sleeves with sleeve-seal system, or Sleeve-seal fittings.
         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: Cast-iron pipe sleeves with sleeve-seal system or 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: Cast-iron pipe sleeves with sleeve-seal system or 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: Cast-iron pipe sleeves with sleeve-seal system or 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 or Stack-sleeve fittings.
   b. Piping NPS 6 and Larger: Steel pipe sleeves or Stack-sleeve fittings
5. Interior Partitions:
   a. Piping Smaller Than NPS 6: Steel pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 230517

SECTION 230518 - 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. BrassCraft Manufacturing Co.; a Masco company.
   2. Jones Stephens Corp.
   3. 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 brass 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 and Relocated Existing Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
      b. Chrome-Plated Piping: One-piece steel or split-plate steel with polished, chrome-plated finish.
      c. Insulated Piping: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
      d. 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.
      e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
      f. Bare Piping in Unfinished Service Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
      g. Bare Piping in Equipment Rooms: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.

   2. Escutcheons for Existing Piping to Remain:
      a. Chrome-Plated Piping: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
      b. Insulated Piping: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
      c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
      d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
      e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
      f. Bare Piping in Equipment Rooms: 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 and Relocated Existing 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 230518

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SECTION 230519 - 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. Filled-system thermometers.
2. Liquid-in-glass thermometers.
3. Duct-thermometer mounting brackets.
4. Thermowells.
5. Dial-type pressure gages.
6. Gage attachments.
7. Test plugs.
8. Test-plug kits.
9. Flowmeters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include diagrams for power, signal, and control wiring.
2. Product Certificates: For each type of meter and gage.

1.4 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
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. Ashcroft Inc.
b. Trerice, H. O. Co.
c. Weiss Instruments, Inc.

2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 3-inch nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Stainless steel.
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.
12. Accuracy: Plus, or minus 1 percent of scale range.

B. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:
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. Ashcroft Inc.
    b. Trerice, H. O. Co.
    c. Weiss Instruments, Inc.
2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch nominal diameter with back flange and holes for panel mounting.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Stainless steel.
10. Connector Type(s): Union joint, back; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.
12. Accuracy: Plus, or minus 1 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
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. Trerice, H. O. Co.
2. Standard: ASME B40.200.
3. Case: Cast aluminum; 9-inch nominal size.

4. Case Form: Back angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid. (non-mercury)
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or plastic.
8. Stem: Aluminum or brass and of length to suit installation.
   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.
9. Connector: 3/4inch, 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. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
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. Flo Fab Inc.
   b. Palmer Wahl Instrumentation Group.
   c. Trerice, H. O. Co.
   d. Weiss Instruments, Inc.
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 (non-mercury).
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass.
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.

2.3 DUCT-THERMOMETER MOUNTING BRACKETS

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

2.4 THERMOWELLS

A. Thermowells:
1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.

8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

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

2.5 DIAL-TYPE PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
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. Ametek U.S. Gauge.
   b. Ashcroft Inc.
   c. Trerice, H. O. Co.
2. Standard: ASME B40.100.
3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

B. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
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. Ametek U.S. Gauge.
   b. Ashcroft Inc.
   c. Trerice, H. O. Co.
2. Standard: ASME B40.100.
3. Case: Liquid-filled type; 4-1/2-inchnominal diameter with back flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range

2.6 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of brass, stainless-steel or steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.7 TEST PLUGS

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. Flow Design, Inc.
   2. Sisco Manufacturing Company, Inc.
   3. Trerice, H. O. Co.
   4. WATTS.

B. Description: Test-station fitting made for insertion in 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 ¼ or NPS 1/2, ASME B1.20.1 pipe thread.

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

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.8 TEST-PLUG KITS

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. Sisco Manufacturing Company, Inc.
   2. Trerice, H. O. Co.
   3. WATTS.

B. Furnish one test-plug kit(s) containing two thermometer(s), 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 with2-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 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 with3-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.

2.9 FLOWMETERS

A. Venturi Flowmeters:
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. ABB (Industrial Automation Division).
   b. Nexus Valve, Inc.
   c. S. A. Armstrong Limited.
   d. Victaulic Company.
2. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.
   a. Design: Differential-pressure-type measurement for water.
   b. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
   c. Minimum Pressure Rating: 250 psig.
   d. Minimum Temperature Rating: 250 deg F.
   e. End Connections for NPS 2 and Smaller: Threaded.
   f. End Connections for NPS 2-1/2 and Larger: Flanged or welded.
   g. Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.
5. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch-diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
   a. Scale: Gallons per minute.
   b. Accuracy: Plus, or minus 1 percent between 20 and 80 percent of scale range.
6. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected flowmeter element and having two 12-foot hoses, with carrying case.
   a. Scale: Gallons per minute.
   b. Accuracy: Plus, or minus 2 percent between 20 and 80 percent of scale range.
7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Conversion Chart: Flow rate data compatible with sensor.
9. Operating Instructions: Include complete instructions with each flowmeter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide components as noted below in PART 3 of this section in addition to those shown on the specific drawing details.

B. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

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

D. Install thermowells with extension on insulated piping.

E. Fill thermowells with heat-transfer medium.

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

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

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

I. Install valve and snubber in piping for each pressure gage for fluids (except steam).

J. Install valve and syphon fitting in piping for each pressure gage for steam.

K. Install test plugs in piping tees.

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

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

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

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

P. 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.

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

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

S. 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 chiller.
   4. Inlet and outlet of each hydronic coil in air-handling units.
   5. Two inlets and two outlets of each hydronic heat exchanger.
   6. Inlet and outlet of each thermal-storage tank.
   7. Outside-, return-, supply-, and mixed-air ducts.

T. Install pressure gages in the following locations:
   1. Discharge of each pressure-reducing valve.
   2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
   3. Suction and discharge of each pump.

U. Provide pressure/temperature (P/T) fittings at inlet and outlet of all terminal equipment coils (reheat coils, unit heaters)

3.2 CONNECTIONS

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

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter 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 one of the following:
   1. Liquid-filled.
   2. Compact-style, liquid-in-glass type.
   3. Test plug with chlorosulfonated polyethylene synthetic 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 one of the following:
   1. Liquid-filled
   2. Compact-style, liquid-in-glass type.
   3. Test plug with chlorosulfonated polyethylene synthetic EPDM self-sealing rubber inserts.

C. Thermometers at inlet and outlet of each hydronic boiler shall be one of the following:
   1. Liquid-filled type.
   2. Industrial-style, liquid-in-glass type.
   3. Test plug with chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber inserts.

D. Thermometers at inlets and outlets of each chiller shall be one of the following:
   1. Liquid-filled type.
   2. Industrial-style, liquid-in-glass type.
   3. Test plug with chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber inserts.

E. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one of the following:
   1. Liquid-filled type.
   2. Compact-style, liquid-in-glass type.
   3. Test plug with chlorosulfonated polyethylene synthetic EPDM self-sealing rubber inserts.

F. Thermometers at outside-, return-, supply-, and energy recovery ducts shall be one of the following:
   1. Liquid-filled type.

2. Compact-style, liquid-in-glass type.

G. 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 Heating, Hot-Water Piping: 30 to 240 deg F.

C. Scale Range for Air Ducts: 0 to 150 deg F.

D. Thermometers shall be installed in the following locations:
1. At the inlet and outlet of equipment such as heating and cooling coils, converters, heat exchangers, etc.
2. Where temperature difference is an indication of equipment performance.
3. At other locations as noted in the specifications and drawing details.

E. Thermometers shall be non-mercury type with 9" case and a maximum of 2oF divisions.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be one of the following:
1. Liquid-filled or Sealed direct-mounted, metal case.
2. Test plug with chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber inserts.

B. Pressure gages at suction and discharge of each pump shall be one of the following:
1. Liquid-filled or Sealed direct-mounted, metal case.
2. Test plug with chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber inserts.

C. Pressure gauges shall be installed in the following locations:
1. Before and after each pressure reducing valve.
2. At the inlet and outlet of mechanical equipment such as condensers, pumps, strainers, heating and cooling coils, converters, heat exchangers, etc.
3. At the inlet of each hydronic expansion tank.
4. Where pressure drop is an indication of equipment performance.
5. At other locations as determined by the Design Consultant.

D. Provide pressure/temperature (P/T) fittings at inlet and outlet of all terminal equipment coils (reheat coils, unit heaters, etc.).

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

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

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

3.8 FLOWMETER SCHEDULE

A. Flowmeters for Chilled-Water Piping: Venturi type.

B. Flowmeters for Heating, Hot-Water Piping: Venturi type.

3.9 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

B. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of four (4) hours of instruction at the site, during start-up.
   3. Provide four (4) hours of instruction at the site after start-up
      a. Provide two (2) hours at three (3) months after start-up training
      b. Provide one (1) hour at six (6) months after start-up training.
      c. Provide one (1) hour at nine (9) months after start-up training.

END OF SECTION 230519

SECTION 230523.12 - BALL 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. Bronze ball valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, and weld ends.
   3. Set ball valves open to minimize exposure of functional surfaces.

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 operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:
   1. ASME B1.20.1 for threads for threaded-end valves.
   2. ASME B16.1 for flanges on iron valves.
   3. ASME B16.5 for flanges on steel valves.
   4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   5. ASME B16.18 for solder-joint connections.
   6. ASME B31.1 for power piping valves.
   7. ASME B31.9 for building services piping valves.

C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

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

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

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

G. Valve Actuator Types:
   1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
   2. Handlever: For quarter-turn valves smaller than NPS 4.

H. Valves in Insulated Piping:
   1. Include 2-inch stem extensions.
   2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
   3. Memory stops that are fully adjustable after insulation is applied.

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

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:
   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. Apollo Flow Controls; Conbraco Industries, Inc.
      b. Milwaukee Valve Company.
      c. NIBCO INC.
      d. WATTS.
   2. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig.
      c. CWP Rating: 600 psig.
      d. Body Design: Two piece.
      e. Body Material: Bronze.
      f. Ends: Threaded.
      g. Seats: PTFE.
      h. Stem: Stainless steel.

i. Ball: Stainless steel, vented.
j. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

A. 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.

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

C. Bronze valves shall comply with ASTM-B61 or B62.

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

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

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

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

E. In general, all valves should be line size with the pipe reduction to the equipment connection done downstream of the valve.

F. Provide isolation valves at all equipment, terminal equipment, main branches, and at the base of each riser.

G. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are unavailable, 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 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
   4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.4 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: bronze ball valves, two piece with stainless-steel trim, full port, threaded, solder or press connection-joint ends.
   1. Valves may be provided with solder-joint ends instead of threaded ends.

3.5 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: bronze ball valves, two piece with stainless-steel trim, full port, threaded, solder or press connection-joint ends.
   1. Valves may be provided with solder-joint ends instead of threaded ends.

END OF SECTION 230523.12

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SECTION 230523.13 - BUTTERFLY 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. Iron, single-flange butterfly valves.
   2. Ductile iron, grooved-end butterfly valves.
   3. High-performance butterfly valves.
   4. Chainwheels.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

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

D. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 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 butterfly valves closed or slightly open.

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.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:
1. ASME B16.1 for flanges on iron valves.
2. ASME B16.5 for pipe flanges and flanged fittings, NPS 1/2 through NPS 24.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B31.1 for power piping valves.
5. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

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

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

F. Valve Actuator Types:
1. Gear Actuator: For valves NPS 8 and larger.
2. Handlever: For valves NPS 6 and smaller.
3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.

G. Valves in Insulated Piping: With 2-inch stem extensions with extended necks.

2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves with Ductile-Iron Disc:
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. Apollo Flow Controls; Conbraco Industries, Inc.
b. Milwaukee Valve Company.
c. NIBCO INC.
d. Red-White Valve Corp.
e. WATTS.
2. Description:
a. Standard: MSS SP-67, Type I compliant.
b. CWP Rating: 150 psig.
c. Body: Material: ASTM A536 ductile iron, full lug-type for use between ANSI 125 Class and 150 Class flanges.
d. Body Design: Lug type Bi-directional flow design, rated for 200 psig bubble-tight shut-off between flanges, with valve seats mechanically retained in valve body. Minimum 2-inch extended neck with mounting flange for actuator.
e. Stem: One- or two-piece stainless steel.

f. Dead-end Service: Integral retainer screws to permit closure against full 200 psig pressure rating of valve without downstream flange.
g. Disc/Shaft: ASTM B148 Aluminum-Bronze disc, with ASTM A564 type 416-Stainless Steel one-piece shaft, and ASTM A276 type 316-Stainless Steel taper pins.
h. Disc shall be offset from the stem centerline to allow full 360 degree seating.
i. Bushings: PTFE.
j. Seat: EPDM with phenolic backing.
k. Shaft Seals: EPDM.
l. Operator for valves up to 6-inch: Lever-lock operator with throttling plate.
m. Operator for valves 8-inches and larger: Manual, self-locking, self-lubricating gear operator with hand-wheel or Babbitt Steam Specialty Co. chain-wheel as determined by installation height of valve.

2.3 DUCTILE-IRON, GROOVED-END BUTTERFLY VALVES

A. Iron, Grooved-End Butterfly Valves, 300 psi CWP:
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. Grinnell G-Fire by Johnson Controls Company.
b. Kennedy Valve Company; a division of McWane, Inc.
c. Tyco by Johnson Controls Company.
d. Victaulic Company.
2. Steel Pipe Description:
a. 300 psi CWP suitable for bidirectional and dead-end service at full rated pressure.
b. Body shall be grooved end black enamel coated ductile iron conforming to ASTM A536.
c. Disc shall be electroless nickel plated ductile iron with blowout proof 416 stainless steel stem.
d. Disc shall be offset from the stem centerline to allow full 360 degree seating.
e. Seat shall be pressure responsive EPDM.
f. Valve bearings shall be TFE lined fiberglass, and stem seals shall be of the same grade elastomer as the valve seat.
g. Valve shall be complete with ISO flange for actuation mounting.
h. Valve operators shall be lever handle or gear operator, available with memory stop feature, locking device, chainwheel, or supplied bare.
i. Basis of Deign: Victaulic S/761
3. Copper Pipe
a. Butterfly Valves: 2-1/2" - 6", 300 psi maximum pressure rating.
b. Cast brass body to UNS C87850 or ASTM A351 Grade CF8M.
c. Aluminum bronze disc to UNS C95500 or ASTM A351 Grade CF8M, with pressure responsive elastomer seat.
d. Stem shall be offset from the disc centerline to provide complete 360-degree circumferential seating. Bubble tight, dead-end, or bi-directional service, with memory stop for throttling, metering, or balancing service.
e. Certified to the low lead requirements of NSF-372.
f. Basis of Deign: Victaulic S/608N or S/461.

2.4 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Single-Flange, High-Performance Butterfly Valves, Class 150:
   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. Apollo Flow Controls; Conbraco Industries, Inc.
      b. Jamesbury; Metso.
      c. Milwaukee Valve Company.
      d. NIBCO INC.
   2. Description:
      a. Standard: MSS SP68 compliant.
      b. Body: ANSI Class 300, fabricated from ASTM A216, Type WCB carbon steel. Full lug-type; suitable for bi-directional dead-end service at rated pressure without use of downstream flange.
      c. CWP Rating: 720 psig at 100 deg F.
      d. Disc/Shaft: Type 316 stainless steel disc, with 17-4 PH stainless steel shaft.
      e. Disc shall be offset from the stem centerline to allow full 360 degree seating.
      f. Seat Material: Non fire-tight type, fabricated from "XTREME" fluoropolymer-based compound. The seat/disc assembly shall be rated for 450 psig/460 degrees F saturated steam service.
      g. Shaft Seals: Carbon-filled enhanced PTFE seal.
      h. Operator: Manual, self-locking, self-lubricating gear operator with hand-wheel or Bobbit Steam Specialty Company chain wheel as determined by installation height of valve.

2.5 CHAINWHEELS

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. Babbitt Steam Specialty Co.
   2. Roto Hammer Industries.
   3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.
   1. Sprocket Rim with Chain Guides: Ductile or cast iron.
   2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. 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.

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

C. Examine mating flange faces for damage. 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.

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

3.2 VALVE INSTALLATION

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

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

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

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

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

F. In general, all valves should be line size with the pipe reduction to the equipment connection done downstream of the valve.

G. Provide isolation valves at all equipment, terminal equipment, main branches, and at the base of each riser.

H. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.3 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.

3.4 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger:
   1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Ductile-iron disc, 200 CWP, and EPDM seat.
   2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: Ductile-iron disc, 150 CWP, and EPDM seat.
   3. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175] CWP.
   4. High-Performance Butterfly Valves: Single flange, Class 150.

3.5 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger:
   1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Ductile-iron disc, 200 CWP, and EPDM seat.
   2. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
   3. High-Performance Butterfly Valves: Single flange, Class 150.

END OF SECTION 230523.13

SECTION 230523.14 - CHECK 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. Bronze lift check valves.
   2. Bronze swing check valves.
   3. Iron swing check valves.
   4. Iron, center-guided check valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

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

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 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. 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.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.1 for power piping valves.
6. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

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

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

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

2.2 BRONZE LIFT CHECK VALVES

A. Bronze Lift Check Valves with Bronze Disc, Class 125:
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. Crane; a Crane brand.
b. Jenkins Valves; a Crane brand.
c. Stockham; a Crane brand.
2. Description:
a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Design: Vertical flow.
d. Body Material: ASTM B61 or ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

2.3 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze Disc, Class 150:

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. Apollo Flow Controls; Conbraco Industries, Inc.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Red-White Valve Corp.
2. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 300 psig.
   c. Body Design: Horizontal flow.
   d. Body Material: ASTM B62, bronze.
   e. Ends: Threaded.
   f. Disc: Bronze.

2.4 IRON SWING CHECK VALVES

A. Iron Swing Check Valves with Metal Seats, Class 125:
   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. Apollo Flow Controls; Conbraco Industries, Inc.
      b. Jenkins Valves; a Crane brand.
      c. Milwaukee Valve Company.
      d. NIBCO INC.
      e. Red-White Valve Corp.
      f. WATTS.
   2. Description:
      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Bronze.
      h. Gasket: Asbestos free.

B. Iron Swing Check Valves with Nonmetallic-to-Metal Seats, Class 125 (CV-4)
   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. Apollo Flow Controls; Conbraco Industries, Inc.
      b. Milwaukee Valve Company.
      c. NIBCO INC.
   2. Description:
      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A126, gray iron with bolted bonnet.

f. Ends: Flanged.
g. Trim: Composition.
h. Seat Ring: Bronze.
i. Disc Holder: Bronze.
j. Disc: PTFE.
k. Gasket: Asbestos free.

2.5 IRON, CENTER-GUIDED CHECK VALVES

A. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 150:
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. APCO Willamette Valve and Primer Corporation.
b. Crispin Valve.
c. DFT Inc.
d. Val-Matic Valve & Manufacturing Corp.
2. Description:
a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
c. NPS 14 to NPS 24, CWP Rating: 250 psig.
d. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: EPDM.

PART 3 - EXECUTION

3.1 EXAMINATION

A. 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.

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

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

D. 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.

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

3.2 VALVE INSTALLATION

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

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

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

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

E. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.
   3. Lift Check Valves: With stem upright and plumb.

F. Install valve tags. Comply with requirements for valve tags and schedules in Section 230553 "Identification for HVAC Piping and Equipment."

3.3 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.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Pump-Discharge Check Valves:
      a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
      b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal, or resilient-seat check valves.

B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. 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.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
   3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
   4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
   6. For Steel Piping, NPS 5 and Larger: Flanged ends.
   7. For Grooved-End Copper Tubing and Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Bronze swing check valves with bronze disc, Class 150.

B. Pipe NPS 2-1/2 and Larger:
   1. NPS 2-1/2 to NPS 4: Iron valves may be provided with threaded ends instead of flanged ends.
   2. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125.

3.6 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Bronze swing check valves with bronze or nonmetallic disc, Class 150.

B. Pipe NPS 2-1/2 and Larger:
   1. NPS 2-1/2 to NPS 4: Iron valves may be provided with threaded ends instead of flanged ends.
   2. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125.

END OF SECTION 230523.14

SECTION 230523.15 - GATE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze gate valves.
2. Iron gate valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. NRS: Nonrising stem.

C. OS&Y: Outside screw and yoke.

D. RS: Rising stem.

E. SWP: Steam working pressure.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 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, press connections, and weld ends.
3. Set gate valves closed to prevent rattling.

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, stems, or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for cast copper solder joint.
5. ASME B16.22 for wrought copper solder joint.
6. ASME B16.34 for flanged, threaded, and welding ends.
7. ASME B31.1 for power piping valves.
8. ASME B31.9 for building services piping valves.

B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

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

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

F. RS Valves in Insulated Piping: With 2-inch stem extensions.

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

2.3 BRONZE GATE VALVES

A. Bronze Gate Valves, NRS, Class 150:

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

a. American Valve, Inc.
b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
c. Milwaukee Valve Company.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.

d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

2.4 IRON GATE VALVES

A. Iron Gate Valves, OS&Y, Class 250:

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

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Hammond Valve.
c. Milwaukee Valve Company.

2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

PART 3 - EXECUTION

3.1 EXAMINATION

A. 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.

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

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

D. 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.

E. Examine press joint surfaces. Verify that they are clean and free from dents and burrs and that O-ring seals are in place and undamaged.

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

3.2 INSTALLATION OF VALVES

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

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.

D. Install valves so that stems are horizontal or slope upward from centerline of pipe.

E. Install valves in position that does not project into aisles or block access to other equipment.

F. Install valves in position to allow full stem and manual operator movement.

G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.

H. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.3 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.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

1. Shutoff Service: Gate valves.

B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:
1. For Steel Piping, NPS 2 and Smaller: Threaded ends.
2. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules.

3.5 HIGH TEMPERATURE HOT WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze valves, NRS, Class 150 with threaded ends.

B. Pipe NPS 2-1/2 and Larger: Iron gate valves, OS&Y, Class 250.

END OF SECTION 230523.15

SECTION 230529 - 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. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment stands.
8. 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 230548.13 "Vibration 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.
1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

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.

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. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. ABB (Electrification Products Division).
      b. Eaton (B-line).

c. Flex-Strut Inc.
d. 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 galvanized steel.
8. Metallic Coating: No coating.
9. Paint Coating: Green epoxy, acrylic, or urethane.

2.5 THERMAL-HANGER SHIELD INSERTS

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. KB Enterprise.
2. National Pipe Hanger Corporation.
3. Pipe Shields Inc.
4. Piping Technology & Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. Hilti, Inc.
b. MKT Fastening, LLC.
c. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Eaton (B-line).
      b. Hilti, Inc.
      c. MKT Fastening, LLC.
   2. Indoor Applications: Zinc-coated steel.
   3. Outdoor Applications: Stainless steel.

2.7 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. 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. PHP Systems/Design.
      b. RectorSeal HVAC; a CSW Industrials Company.
      c. Rooftop Support Systems, a division of Eberl Iron Works, Inc.
   2. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
   3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
      a. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 70 percent.
   4. Hardware: Galvanized steel or polycarbonate.
   5. Accessories: Protection pads.

C. Low-Profile, Single Base, Single-Pipe Stand:
   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. MIRO Industries.
      b. PHP Systems/Design.
      c. Rooftop Support Systems, a division of Eberl Iron Works, Inc.
   2. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
   3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
      a. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 70 percent.
   4. Vertical Members: Two, galvanized-steel, continuous-thread 1/2-inch rods.
   5. Horizontal Member: Adjustable horizontal, galvanized-steel pipe support channels.
   6. Pipe Supports: Roller.
   7. Hardware: Galvanized steel.
   8. Accessories: Protection pads.
   9. Height: 12 inches above roof.

D. High-Profile, Single Base, Single-Pipe Stand:
   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. MIRO Industries.
      b. PHP Systems/Design.
      c. Rooftop Support Systems, a division of Eberl Iron Works, Inc.
   2. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   3. Base: Single vulcanized rubber or molded polypropylene.
      a. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 70 percent.
   4. Vertical Members: Two, galvanized-steel, continuous-thread 1/2-inch rods.
   5. Horizontal Member: One, adjustable height, galvanized--steel pipe support slotted channel or plate.
   6. Pipe Supports: Roller.
   7. Hardware: Galvanized steel.
   8. Accessories: Protection pads, 1/2-inch continuous-thread galvanized-steel rod.
   9. Height: 36 inches above roof.

E. High-Profile, Multiple-Pipe Stand:
   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. MIRO Industries.
      b. PHP Systems/Design.
      c. RectorSeal HVAC; a CSW Industrials Company.
      d. Rooftop Support Systems, a division of Eberl Iron Works, Inc.
   2. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
   3. Bases: Two or more; vulcanized rubber.
      a. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 70 percent.
   4. Vertical Members: Two or more, galvanized-steel channels.
   5. Horizontal Members: One or more, adjustable height, galvanized-steel pipe support.
   6. Pipe Supports: Roller.
   7. Hardware: Galvanized steel.
   8. Accessories: Protection pads, 1/2-inch continuous-thread rod.
   9. 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.

2.8 EQUIPMENT SUPPORTS

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

2.9 OUTDOOR EQUIPMENT STANDS

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. MIRO Industries.
   2. RectorSeal HVAC; a CSW Industrials Company.
   3. Rooftop Support Systems, a division of Eberl Iron Works, Inc.

2.10 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. 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.

B. 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.

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

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

E. Fastener System Installation:
1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. 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.

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

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

I. 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.

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

K. 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.

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

M. 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.

N. 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.
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" and Section 099123 "Interior 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 copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

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

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

I. 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.

J. 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.

K. 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.

L. 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 attached to side of the waffle rib.
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.

M. 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.

N. 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.

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

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

Q. Maximum hanger spacing shall comply with the 2020 Mechanical Code of New York State Table 305.4

§MC305.4 Interval of support.
Piping shall be supported at distances not exceeding the spacing specified in Table MC305.4, or in accordance with ANSI/MSS SP-58.

TABLE MC305.4
PIPING SUPPORT SPACING[a]

TABLE 305.4
PIPING SUPPORT SPACING[a]

PIPING MATERIAL	MAXIMUM HORIZONTAL SPACING (feet)	MAXIMUM VERTICAL SPACING (feet)
ABS pipe	4	10[c]
Aluminum pipe and tubing	10	15
Cast-iron pipe[b]	5	15
Copper or copper-alloy pipe	12	10
Copper or copper-alloy tubing	8	10
CPVC pipe or tubing, 1 inch and smaller	3	10[c]
CPVC pipe or tubing, $1^1/_4$ inches and larger	4	10[c]
Lead pipe	Continuous	4
PB pipe or tubing	$2^2/_3$ (32 inches)	4
PE-RT 1 inch and smaller	$2^2/_3$ (32 inches)	10[c]
PE-RT $1^1/_4$ inches and larger	4	10[c]
PEX tubing 1 inch and smaller	$2^2/_3$ (32 inches)	10[c]
PEX tubing $1^1/_4$ inches and larger	4	10[c]
Polypropylene (PP) pipe or tubing, 1 inch and smaller	$2^2/_3$ (32 inches)	10[c]
Polypropylene (PP) pipe or tubing, $1^1/_4$ inches and larger	4	10[c]
PVC pipe	4	10[c]
Steel tubing	8	10
Steel pipe	12	15

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. See Section 301.18.
b. The maximum horizontal spacing of cast-iron pipe hangers shall be increased to 10 feet where 10-foot lengths of pipe are installed.
c. Mid-story guide.

END OF SECTION 230529

SECTION 230548.13 - VIBRATION CONTROLS 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. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient support.
9. Resilient pipe guides.
10. Sliding Guide
11. Elastomeric hangers.
12. Spring hangers.
13. Snubbers.
14. Restraints - rigid type.
15. Restraints - cable type.
16. Restraint accessories.
17. Post-installed concrete anchors.
18. Concrete inserts.
19. Vibration isolation equipment bases.
20. Restrained isolation roof-curb rails.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.4 ACTION SUBMITTALS

A. Product Data:
1. For each type of product.
2. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

3. Include load rating for each wind-force-restraint fitting and assembly.
4. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device component.
5. Annotate to indicate application of each product submitted and compliance with requirements.
6. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:
1. Detail fabrication and assembly of equipment bases.
2. 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.
3. Coordination Drawings: Show coordination of vibration isolation device installation for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints.
4. Qualification Data: For testing agency.
5. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-spring mounts and restrained-air-spring mounts to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7 and be acceptable to authorities having jurisdiction.

B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
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. Kinetics Noise Control, Inc.
b. Vibration Eliminator Co., Inc.
c. Vibration Mountings & Controls, Inc.
2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Minimum deflection as indicated on Drawings.

5. Pad Material: Oil- and water-resistant rubber.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and elastomeric.
    a. Surface Pattern: Smooth, ribbed, or waffle pattern.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:
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. Isolation Technology, Inc.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc.
    d. Vibration Isolation.
2. Mounting Plates:
    a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
    b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
3. Elastomeric Material: Molded, oil- and water-resistant neoprene rubber, silicone rubber, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:
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. Isolation Technology, Inc.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc.
    d. Vibration Isolation.
2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
    a. Housing: Cast-ductile iron or welded steel.
    b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:
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. Isolation Technology, Inc.

b. Kinetics Noise Control, Inc.
c. Mason Industries, Inc.
d. Vibration Isolation.

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. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.5 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:
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. Isolation Technology, Inc.
b. Kinetics Noise Control, Inc.
c. Mason Industries, Inc.
d. Vibration Isolation.
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. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
b. Top housing with attachment and leveling bolt.

2.6 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
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. Isolation Technology, Inc.
b. Kinetics Noise Control, Inc.
c. Mason Industries, Inc.
d. Vibration Isolation.
2. Housing: Steel housing with vertical limit stops to prevent spring extension due to weight being removed.

a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
b. Top plate with threaded mounting holes
c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.7 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
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. Isolation Technology, Inc.
b. Kinetics Noise Control, Inc.
c. Mason Industries, Inc.
d. Vibration Isolation.
2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
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.

2.8 PIPE-RISER RESILIENT SUPPORT

A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch-Thick Neoprene:
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. Kinetics Noise Control, Inc.
b. Mason Industries, Inc.
c. Vibration Eliminator Co., Inc.
2. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.

3. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.9 RESILIENT PIPE GUIDES

A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch-Thick Neoprene:
   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. Kinetics Noise Control, Inc.
      b. Mason Industries, Inc.
      c. Vibration Eliminator Co., Inc.
      d. Vibration Management Corp.
   2. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.10 SLIDING GUIDE

A. Steel plate guides sliding on steel plate shoe.

B. Vertical plate steel tee to be welded to steel pipe.

2.11 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
   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. Kinetics Noise Control, Inc.
      a. Mason Industries, Inc.
      b. Vibration Eliminator Co., Inc.
      c. Vibration Isolation.
   3. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
   4. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.12 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
   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. Kinetics Noise Control, Inc.
b. Mason Industries, Inc.
c. Vibration Eliminator Co., Inc.
d. Vibration Isolation.

2. 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.
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.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 SNUBBERS

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. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Vibration Management Corp.

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be seismically prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI 318-14 Ch. 17 for 2015 or 2018 IBC.
2. Preset Concrete Inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.
3. Anchors in Masonry: Design in accordance with TMS 402.
4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.14 RESTRAINTS - RIGID TYPE

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. Eaton (B-line).
2. Hilti, Inc.
3. TOLCO.
4. Vibration Mountings & Controls, Inc.

B. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes 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; rated in tension, compression, and torsion forces.

2.15 RESTRAINTS - CABLE TYPE

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. Eaton (B-line).
2. nVent (CADDY).
3. Vibration Mountings & Controls, Inc.

B. Restraint Cables: ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

C. Restraint cable assembly with cable fittings must comply with ASCE/SEI 19. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.16 RESTRAINT ACCESSORIES

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. Eaton (B-line).
2. Hilti, Inc.
3. Mason Industries, Inc.
4. TOLCO.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. 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.

E. 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.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.17 POST-INSTALLED CONCRETE ANCHORS

A. Shall be per section 230529

2.18 CONCRETE INSERTS

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. Eaton (B-line).
   2. Hilti, Inc.
   3. Mason Industries, Inc.
   4. Powers Fasteners.
   5. Simpson Strong-Tie Co., Inc.

B. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC466 testing.

C. Comply with ANSI/MSS SP-58.

2.19 VIBRATION ISOLATION EQUIPMENT BASES

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. Kinetics Noise Control, Inc.
   2. Mason Industries, Inc.
   3. Vibration Eliminator Co., Inc.
   4. Vibration Isolation.

B. Steel Rails: Factory-fabricated, welded, structural-steel 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 rails.
      a. Include supports for suction and discharge elbows for pumps.
   2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails 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.

C. Steel Bases: 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 A36/A36M. 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.

D. Concrete Inertia Base: Factory-fabricated or field-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 A36/A36M. 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.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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 wind-load forces.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static and wind force loads within specified loading limits.

3.3 INSTALLATION OF VIBRATION CONTROL DEVICES

A. Provide vibration control devices for systems and equipment where indicated in the equipment schedules, shown on the equipment drawings and equipment details, or as required by the equipment manufacturer for proper operation. The technical specifications indicate where isolators are to be installed on specific equipment and systems, and where required by applicable codes.

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

C. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

D. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

E. Equipment Restraints:
1. Install 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 wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

F. 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.

G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

H. 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.

I. 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.

J. Post-Installed Concrete 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 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. **Do not anchor into tile portion of the existing waffle slab floor**.
4. Wedge-Type Anchor Bolts: 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.
5. Adhesive-Type Anchor Bolts: 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.
6. Set anchors to manufacturer's recommended torque, using a torque wrench.
7. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 INSTALLATION OF AIR-SPRING ISOLATORS

A. Independent Isolator Installation:
   1. Install automatic leveling valve into each air isolator.

3.5 ACCOMMODATION OF DIFFERENTIAL MOTION

A. Provide flexible connections in piping systems where they cross structural joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for piping flexible connections.

3.6 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES

A. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Coordinate dimensions of equipment bases with requirements of isolated equipment specified in this and other Sections. Where dimensions of base are indicated on Drawings, they may require adjustment to accommodate isolated equipment.

3.7 ADJUSTING

A. Adjust isolators after 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.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will 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. Tests and Inspections:
   1. Perform tests and inspections with the assistance of a factory-authorized service representative
   2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   3. 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.
   4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

5. Test no fewer than Twenty (20) of each type and size of installed anchors and fasteners selected by Architect.
6. Test to 90 percent of rated proof load of device.
7. Measure isolator restraint clearance.
8. Measure isolator deflection.
9. Verify snubber minimum clearances.
10. Test and adjust restrained-air-spring isolator controls and safeties.

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 230548.13

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SECTION 230552 – MOTOR STARTERS AND SPEED CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Starters
   2. Variable Speed Drive System
   3. High efficiency electric motors

B. Related Documents: The Contract Documents, as defined in Section 01110 - Summary of Work, apply to the Work of this Section. Additional requirements and information necessary to complete the Work of this Section may be found in other Documents.

C. Related Sections:
   1. Division 26 - Basic Electrical Materials and Methods: Basic electrical methods.

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE):
   1. IEEE 519-1992 - Harmonic Distortion Standard.

B. National Electrical Contractors Association (NECA):
   1. NECA SI - Standard of Installation.

C. National Electrical Manufacturers Association (NEMA):

D. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code.

1.3 DESCRIPTION

A. Work Included:
   1. Provide all labor, materials, equipment, and services to:
      a. Furnish all wiring diagrams, equipment connection sizes, etc., required affecting the work of the other trades.
      b. Provide all control wiring associated with the BAS including but not limited to temperature control components, equipment starting circuits and building fire alarm systems for fan shutdown.
      c. Provide all power wiring not otherwise covered elsewhere in the contract specifications. This includes but is not limited to power for all control panels, transformers, controllers, relays, actuators, etc. Connect to nearest available 120 volt power circuits, coordinate with the Electrical Contractor.
      d. All wiring to be installed in accordance with the NEC.
      e. Provide electrical devices for mechanical equipment as listed in Part 2 – Schedule.

B. Required Work Specified Elsewhere:

1. It is the general intent that all electrical power wiring, motor starters, variable speed drives and power disconnects be provided and installed by the Electrical Contractor. Some Mechanical equipment is specified to have factory installed integral starters, variable speed drives and /or power disconnects and as such are to be provided by the Mechanical Contractor. REFER TO THE MOTOR CONNECTION SCHEDULE FOR ALL REQUIREMENTS.

1.4 SUBMITTALS

A. PRODUCT DATA
1. Submit shop drawings and/or construction details of wiring diagrams for alarms, controls, and equipment.
2. Product Data:
   a. Product Specifications.
   b. Descriptive Bulletins
3. Assurance/Control Submittals:
   a. Certificates: Manufacturer's certificate that Products meet or exceed specified requirements.
   b. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

B. CLOSEOUT SUBMITTALS:
1. Project Record Documents: Record actual locations, ratings, and sizes of variable speed drives.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with Manufacturer’s recommendations and as specified herein.

B. Manufacturer Qualifications: Company specializing in manufacturing Products specified in this Section with minimum five years documented experience.

C. Regulatory Requirements:
1. Conform to requirements of NFPA 70.
2. Products: Listed and classified by Underwriters Laboratories, Incorporated as suitable for purpose specified and indicated.

1.6 MAINTENANCE

A. Closeout Submittals: Procedures for closeout submittals.

B. Extra Products: At completion of installation, deliver to Contracting Officer.
1. Three of each size and type fuse installed.

PART 2 - PRODUCTS

2.1 ELECTRIC WIRING

A. Refer to appropriate sections in Division 26 – Electric.

2.2 MANUAL STARTERS

A. Manual Single-Phase Starters for fractional horsepower.

B. Quick-make, quick-break toggle type with overload field adjustment of +10% of the ratings of the nominal heater value.

C. Provide pilot light and name plate.

D. NEMA 1 enclosure indoors. NEMA 4 enclosures outdoors.

2.3 MAGNETIC STARTERS

A. Across-the-line magnetic starters for motors up to 100 HP, 600 volts, Square D Class 8536; built and tested in accordance with the latest NEMA standards.

B. Equip with three overload relays. Overload shall have +15% adjustment from nominal heater rating to compensate for ambient conditions, or to provide closer overload protection upon installation; provide two field convertible contacts in addition to the hold in contact. Minimum starter size NEMA 0.

C. NEMA 1 enclosure indoors. NEMA 4 enclosure outdoors.

D. Indicating lights: NEMA 1CS2; Run-red in front cover.

E. Hand-off-auto selector switch in front cover.

2.4 CONTROL

A. Provide with 120 volt transformers as required, unless detailed otherwise.

2.5 VARIABLE FREQUENCY DRIVES

A. MANUFACTURERS
1. Variable Speed Drives and Motors: Subject to compliance with project requirements, manufacturers offering Products which may be incorporated in the Work include the following:
   a. ABB
   b. Danfoss
   c. Yaskawa
2. Section 01600 - Product Requirements: Product options and substitutions.
3. Basis of design – Manufacture ABB Model ACH 550 or equal

B. VARIABLE SPEED DRIVE EQUIPMENT (VSD):
1. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase

induction motor by adjusting output voltage and frequency. Drive System shall be compatible with electrical characteristics of motors furnished and rated for operation with equipment furnished.

2. Output Rating: 3-phase, 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.
3. Unit Operating Requirements:
   a. Internal Adjustability:
      1) Minimum Speed: 5 to 25 percent of maximum rpm.
      2) Maximum Speed: 80 to 100 percent of maximum rpm.
      3) Acceleration: 2 to a minimum of 22 seconds.
      4) Deceleration: 2 to a minimum of 22 seconds.
      5) Current Limit: 50 to a minimum of 110 percent of maximum rating.
   b. Self-Protection and Reliability Features :
      6) Input transient protection by means of surge protectors.
      7) Loss of input signal protection.
      8) Under- and overvoltage trips; inverter overtemperature, overload, and over-current trips.
      9) Adjustable motor overload relays.
      10) Critical frequency rejection.
      11) Instantaneous line-to-line and line-to-ground overcurrent trips.
      12) Loss-of-phase protection.
      13) Reverse-phase protection.
      14) Short-circuit protection.
      15) Motor overtemperature fault.
   c. Automatic reset/restart.
   d. Power-interruption protection.
   e. Bidirectional autospeed search.
   f. Torque boost.
   g. Motor temperature compensation at slow speeds.
   h. Integral Disconnecting Means: NEMA KS 1, non-fusible switch with lockable handle.

C. CONTROLS AND INDICATION:
   1. Door-mounted LED status lights.
      a. Power on.
      b. Run.
      c. Overvoltage.
      d. Line fault.
      e. External fault.
   2. Indicating Devices: Meters and digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
      a. Output frequency (Hertz).
      b. Motor speed (RPM).
      c. Motor status (running, stop, fault).
      d. Motor current (amperes).
      e. Motor torque (percent).
      f. Fault or alarming status (code).
      g. Proportional-integral-derivative (PID) feedback signal (percent).
      h. DC-link voltage (volts direct current).
      i. Set-point frequency (Hertz).
      j. Motor output voltage (volts).

3. Control Signal Interface
   a. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 4-20 mA) and 6 programmable digital inputs.
   b. Remote signal inputs capable of accepting any of the following speed-setting input signals from the control system.
      1) 0-10-V dc.
      2) 0-20 or 4-20mA.
      3) Fixed frequencies using digital inputs.
      4) RS484.
      5) Keypad display for local hand operation.
   c. Output signal interface with a minimum of 1 analog output signal (4-20mA), which can be programmed to any of the following:
      1) Output frequency (Hertz).
      2) Output current (load).
      3) DC-link voltage (volts direct current).
      4) Motor Torque (percent).
      5) Motor speed (rpm).
      6) Set-point frequency (Hertz).
   d. Remote indication interface with a minimum of 2 dry circuit relay outputs (12-V ac, 1A) for remote indication of the following:
      1) Motor running.
      2) Set-point speed reached.
      3) Fault and warning indication (overtemperature or overcurrent).
      4) High- or low-speed limits reached.
   e. Integral Control Power Transformer (CPT)
      1) Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses.
      2) CPT Capacity: 200 VA.
4. Communications Port: RS-232 port, USB 2.0 port, or equivalent connection.

D. ADDITIONAL FEATURES:
1. System shall feature the following additional characteristics:
   a. Digital electronic control suitable for application.
   b. Comply with IEEE 519-1992 Harmonic Distortion standard.
   c. Keypad for local operator control and monitoring of setup and fault indications. Keypad functions shall include Start/Stop, Hand/Off/Auto, Manual Speed Selection, Password protection.
   d. Computer port suitable for connection to BACnet compatible Building Automation system (BAS). Where BAS does not exist, provide for future connection, programming and control capability as specified.
   e. Configured for BAS control, configuration and monitoring equal to Keypad.
   f. NEMA labeled enclosure suitable for installation location environment.
   g. Avoidance bands to lockout mechanical resonance points (minimum two points).
   h. Short circuit and surge protection.
   i. Ability to start into a rotating condition.
   j. Protection against overcurrent, over-temperature, phase loss.
   k. Operator capability to set maximum and minimum operating speeds.
   l. Operator capability to reset control input setpoint at BAS.
   m. All electronic parameter control. No potentiometers or other non-electronic adjustments permitted.

n. Operator capability to set ramp up and ramp down times (acceleration and deceleration) via BAS.
o. Integral harmonic filters to reduce total current harmonic levels within 5 percent.
p. At the rated full load current of the motor, the output voltage and frequency of the VSD shall equal the full load current rating of the motor.
q. For motors requiring a high starting torque (i.e.: reciprocating pumps and compressors, conveyors, screw pumps and compressors, other positive displacement pumps), the locked rotor current rating of the motor shall be used in selecting the VSD.
r. Operator capability to manually bypass the system to constant speed mode in the event of VSD failure.
s. Capability for operator to view and change all setpoints and sensed points at the site depending on password level using simple menu driven displays. All setpoint and sensed data shall be displayed and labeled on drive unit with English descriptors (no special codewords shall be required) and shall be shown with appropriate engineering units.

2. Programmable settings shall be held in non-volatile flash memory, not affected by power interruption or loss, or be backed up by a battery capable maintaining the program for a minimum of 72 hours.

E. HIGH EFFICIENCY DRIVE EQUIPMENT:
1. Motors shall conform to the latest applicable requirements of NEMA, IEEE, ANSI, NEC and be U.L. listed. Motors shall be designed for continuous duty. Motors shall feature an engraved, stainless steel nameplate listing horsepower, volts, phase, rated and full load amps, model and serial numbers.
2. All new motors furnished on this project shall be high efficiency type rated as noted on drawings.
3. Motors 1 hp or greater in continuous service shall be premium efficiency type as listed in Table 12-12 of NEMA MG-1 Standards.
4. Motors connected to variable frequency drives must be inverter rated.
5. Sealed ball bearings shall be used to reduce maintenance frequency and discourage over-greasing.
6. All new motors furnished on this project shall be furnished with variable frequency drives and non-fused disconnects as recommended by the motor manufacture

2.6 ELECTRONICALLY COMMUTATED MOTOR (ECM) CONTROLLER

A. Manufacturer PRICE Deluxe ECM Speed Controller Basis of Design

B. General
1. The ECM speed controller shall work with a high efficiency ECM motor. The low voltage (24VAC) speed control allows full manual (push button adjust) or BAS (2-10VDC signal) control of the ECM motor.

C. Features:
1. Dual outputs for controlling 2 ECM motors
2. Red four-digit digital display for reading out:
a. Speed 0 -100%
b. Motor RPM
c. BAS input voltage
3. Building Automation System input (2-10VDC) for remote control

D. LED Digital Display
1. The Digital Display indicates several modes of operation to allow for easier and more precise field adjustment and troubleshooting.
2. Local setpoints are stored to EEPROM and will remain set after power failures.
3. Control the 24VAC signal or BAS signal to turn the ECM motor on and off. The ECM motor has large capacitors that charge quickly on mains power up. Switching on several motors frequently could reduce building power quality.

Specifications		
Display	**Mode**	**Range**
L.SEt	Local Setpoint - Manual Speed Adjust Mode (use UP/DOWN to adjust)	0-100%
rPn	RPM - Shows current RPM mode of ECM motor 1. If E001 is displayed – no RPM pulses are being read. Check 6 position cable. If E002 is displayed – RPM reading is over 3000 RPM. Check primary air.	0-2500 RPM
bAS.r	BAS remote - BAS Mode – Voltage Signal (Max display reading is 9.99 VDC)	0-9.99 VDC
bAS.S	BAS Setpoint - Current BAS setpoint	0-100%

priceindustries.

Power:	24 VAC +-10% @ 50/60Hz (2VA)
Operating Conditions:	0°C to 50°C (32°F to 122°F) 0% – 95% R.H. non-condensing
Storage Conditions:	-30°C to 50°C (-22°F to 122°F) 0% – 95% R.H. non-condensing
Processor:	8-bit enhanced flash microcontroller
Inputs:	1 Analog (BAS) and 3 digital inputs (push buttons and RPM)
Outputs:	2 Digital (GO signal to ECM and Vspd PWM signal @ 80.0 Hz), Display, and aux analog output
Connections:	¼" Spade Terminals – Recommend 16 - 22AWG copper wire
Dimensions:	2.8" by 3.8" [71mm by 96mm] (includes mounting plate)
Shipping Weight:	0.220 lbs, 100 grams

E. BAS Input Signal
1. The BAS input signal overrides the local setpoint using a remote 0 – 10VDC signal. If the BAS signal drops below 1VDC local control (via the push buttons) is restored.

BAS Voltage	**Response**	**Notes**
0-1VDC	Local Control mode using push buttons	Local setpoint can be adjusted from 0 – 100 (%) using push buttons
1-2VDC	Motor Off	Recommend sending a 1.5VDC signal to command motor off
2-9VDC	Modulating Control	2 – 9VDC modulates motor from 0-100%
9-10VDC	Maximum Speed	Motor is running at maximum speed. (100%)

F. Analog RPM Output Signal
1. A two wire connection supplies an analog (0-10VDC) signal that is directly proportional to the MOTOR 1 RPM. The range is 0 – 2500 RPM and it will output a proportional 0 – 10VDC signal. If a dual blower system is used only the RPM from motor 1 can be read.

2. The minimum speed of the ECM motor is approximately 250 RPM. Formula for outputs below (tolerance +- 5%):
   a. VDC output = (RPM / 250)
   b. RPM = (VDC * 250)
3. Output signal: 0 – 10VDC @ 20k ohm minimum input impedance and is short circuit protected (Output impedance is 511 ohm to protect against incorrect wiring).
   a. Black wire – ANALOG RPM OUTPUT COM
   b. White wire – ANALOG RPM OUTPUT + (SIGNAL)

2.7 USE

A. Use manual starters on single phase motors ¼ hp and above that require no remote control.

B. Use magnetic starters on three-phase motors and on single-phrase motors requiring remote control.

C. Combination starters may be used where both a disconnect and a starter are required.

D. Variable Frequency Drives for pump and fan motors as identified on the drawings

E. EMC speed controllers shall be used with all EMC motors on Pumps and AHU Fans that are 10 HP or less.

PART 3 - EXECUTION

3.1 GENERAL

A. Wiring Diagrams:
   1. Provide wiring diagrams for all equipment and systems installed as part of the Mechanical Work and in time for roughing of conduit and equipment connections. Wiring diagrams to clearly indicate all items to be mounted and/or wired as part of the work of Division 26.

B. Responsibility:
   1. Check all electrical wiring pertaining to equipment in Mechanical Work for compliance with specifications and correctness of connections. Pay all costs incurred to correct wiring in event equipment or devices fail to function in manner specified, whether due to incorrect connections or improper information and wiring diagrams.

C. Power Wiring:
   1. If equipment other than specified is approved and supplied by the Contractor provide circuit size and conductor size as required to support item supplied by the contractor that deviates for the original design intent.

D. Control Wiring
   1. Control wiring (120 volts single phase A.C. or less OR any D.C. voltage) and mounting of any related control wiring equipment is the responsibility of the Mechanical Contractor.

3.2 ELECTRIC WIRING

A. Electric wiring shall be installed in accordance with all local and state codes and regulations having jurisdiction.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Verify at site the space available for each piece of equipment.

B. Refer to Engineer for any correction, discrepancy, or suggested change in size of location.

C. All equipment and fixture mountings, wiring devices, and accessories (clips, supports, etc.) to be securely fastened to structure with screws, bolts, etc. Nailing not permitted. Do not support or hang any equipment, or conduit from roof deck.

3.4 EXAMINATION

A. Section 01700 - Execution Requirements: Verification of existing conditions before starting work.

B. Verification of Conditions: Verify that field measurements, surfaces, substrates, and conditions are as required, and ready to receive Work.

C. Report in writing to Contracting Officer prevailing conditions that will adversely affect satisfactory execution of the Work of this Section. Do not proceed with Work until unsatisfactory conditions have been corrected.

D. By beginning Work, Contractor accepts conditions and assumes responsibility for correcting unsuitable conditions encountered at no additional cost to the United States Postal Service.

3.5 INSTALLATION

A. Variable Speed Drives:
   1. Provide a digital, electronic variable speed drive system that is compatible with the equipment to be controlled and suitable for the application.
   2. Provide the services of a factory trained technician to assist in installation, startup, and training of Postal Service personnel. Provide filters or other accessories as required to minimize harmonic noise in controlled motors.
   3. Connect new VSD’s to operate equipment and be controlled by BAS or other method as specified. BAS Controller shall operate all VSD’s according to the sequence of operations. VSD control systems requiring operator to make changes at drive unit are not acceptable.
   4. Connect VSD to BAS using either twisted pair or shielded cable as required for system furnished. Check that RPM/HERTZ and other readings at BAS are equal to readings at VSD panel. Insure that system is properly grounded and all connections are properly torqued to manufacturer’s recommendations.
   5. Set minimum speed to allow proper motor cooling and lubrication (normally 20 percent).
   6. Mount VSD (normally on wall) to allow for less than 25 feet of lead length between the drive and motor to prevent voltage reflection. Allow for proper air flow around

VSD for cooling and service access. Check for over-voltage by measuring the phase-phase voltage at the motor terminals.

7. Provide line reactors with 3 to 5 percent impedance or use filter device between drive and motor where required to compensate for power fluctuations (surges and drops).
8. Mount drive in location to provide adequate ventilation for heat dissipation. Provide dust free enclosure with exterior heat sink where required by environment.
9. Coordinate startup and testing with controls contractor. All controls shall be installed and ready to function in accordance with the sequence of operations prior to final testing and training. Adjust controller to update minimum of twice per second.
10. Where multiple pump or fan systems are designed to operate in parallel, adjust VSD to maintain speeds within 20 revolutions per minute of each other when multiple motors are operating.

B. High Efficiency Motors:
1. Provide high efficiency drive motors that are compatible with digital electronic variable speed drive systems and suitable for the application.
2. Securely mount and connect new motors to new VSD in accordance with manufacturer's recommendations, the National Electrical Code and as noted above. Size wiring as specified and per the NEC. All wiring shall be run in conduit suitable for the application.
3. For three phase motors, verify direction of rotation. Verify proper grounding. Check phase to phase voltage and phase to ground voltage. Report results to the Contracting Officer.
4. Torque all connections per manufacturer's recommendations.
5. Provide thermal overloads in starter sized for the application.
6. Check operation of system complies with the sequence of operations.

3.6 FIELD QUALITY CONTROL

A. Quality Control: Field testing and inspection.

3.7 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

B. The following training shall be accomplished after the completion of each phase
1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
2. Provide a total of eight (8) hours of instruction at the site, during start-up.
3. Provide four (6) hours of instruction at the site after start-up
   a. Provide two (2) hours at three (3) months after start-up training
   b. Provide one (2) hour at six (6) months after start-up training.
   c. Provide one (2) hour at nine (9) months after start-up training

END OF SECTION

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SECTION 230553 - IDENTIFICATION 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. 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

1. Product Data: For each type of product.
2. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
3. Valve numbering scheme.
4. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
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. Craftmark Pipe Markers.
b. Marking Services, Inc.
c. Seton Identification Products; a Brady Corporation company.

2. Material and Thickness: Brass, 0.032-inch, or stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
3. Letter Color: Blue
4. Background Color: White.
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-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
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. Craftmark Pipe Markers.
   b. Marking Services, Inc.
   c. Seton Identification Products; a Brady Corporation company.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
3. Letter Color: Blue
4. Background Color White.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. 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-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. 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) and 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. 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. Craftmark Pipe Markers.
2. Marking Sevices Inc.
3. Seton Identification Products; a Brady Corporation company.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: White.

D. Background Color: Red.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. 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-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

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. Craftmark Pipe Markers.
   2. Marking Sevices Inc.
   3. Seton Identification Products; a Brady Corporation company.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include 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: Size letters according to ASME A13.1 for piping, at least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 DUCT LABELS

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. Craftmark Pipe Markers.
   2. Marking Sevices Inc.

3. Seton Identification Products; a Brady Corporation company.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: White.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. 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-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include 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.

2.5 STENCILS

A. Stencils for Piping:
   1. NOT ALLOWED

B. Stencils for Ducts:
   1. NOT ALLOWED

C. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:
   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. Brimar Industries, Inc.
      b. Craftmark Pipe Markers.
      c. Marking Sevices Inc.
   2. Lettering Size: Size letters according to ASME A13.1 for piping, At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
   3. Stencil Material: Aluminum

4. Stencil Paint: Exterior, gloss, alkyd enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
5. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

2.6 VALVE TAGS

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. Craftmark Pipe Markers.
   2. Marking Sevices Inc.
   3. Seton Identification Products; a Brady Corporation company.

B. Description: 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 chain or beaded chain or S-hook.

C. 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. 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. Craftmark Pipe Markers.
   2. Marking Sevices Inc.
   3. Seton Identification Products; a Brady Corporation company.

B. Description: 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: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surface of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

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.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting”

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Locate labels near points where pipes enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

D. Pipe Label Color Schedule:
   1. Chilled-Water Piping: White letters on a safety-green background.
   2. Condenser-Water Piping: White letters on a safety-green background
   3. Heating Water Piping: White letters on a safety-green background
   4. Refrigerant Piping: Black letters on a safety-orange background

3.5 DUCT LABEL INSTALLATION

A. Install plastic-laminated or self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
   1. Blue: For cold-air supply ducts.
   2. Yellow: For hot-air supply ducts.
   3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 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:
      a. Chilled Water: 2 inches, round.
      b. Refrigerant2 inches, round.
      c. Hot Water: 2 inches, round.
   2. Valve-Tag Colors:
      a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.
      b. Flammable Fluids: Black letters on a safety-yellow background.
      c. Combustible Fluids: White letters on a safety-brown background.
      d. Potable and Other Water: White letters on a safety-green background.
      e. Compressed Air: White letters on a safety-blue background.
      f. Defined by User: White letters on a safety-purple background, black letters on a safety-white background, white letters on a safety-gray background, and white letters on a safety-black background.

3.7 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 230553

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SECTION 230593 - 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. Testing, Adjusting, and Balancing of Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.
   2. Testing, Adjusting, and Balancing of Hydronic Piping Systems:
      a. Variable-flow hydronic systems.
      b. Primary-secondary hydronic systems.
   3. Testing, adjusting, and balancing of equipment.
   4. Sound tests.
   5. Vibration tests.
   6. Duct leakage tests verification.
   7. Pipe leakage tests verification.
   8. HVAC-control system verification.

B. Air System and Water System Test and Balance
   1. Air and water system testing, measurement, and data collection shall comply with the requirements of ASHRAE Standard 111.
   2. Balancing of air and water systems shall be specified to be performed by an AABC, NEBB, TABB or SMACNA member who has been certified for a minimum of 5 years.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

F. TDH: Total dynamic head.

G. UFAD: Underfloor air distribution.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference at Project site 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. Plan 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. Qualification Data: Within 30 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.
   4. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.
   5. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.
   6. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.
   7. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
   8. Sample report forms.
   9. Instrument calibration reports, to include the following:
      a. Instrument type and make.
      b. Serial number.
      c. Application.
      d. Dates of use.
      e. Dates of calibration.

B. Certified TAB reports.

1.6 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.

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

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
   1. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

E. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.7 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 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, gauge 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 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.

F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. 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.

I. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible, and their controls are connected and functioning.

J. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.

K. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Examine operating safety interlocks and controls on HVAC equipment.

O. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

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.

Q. Comply with 2020 NYSECC C408.2.3.

3.2 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 in accordance with 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 gauge 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.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance", ASHRAE 111 or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Air handlers shall be tested with related AHU that share ERV and fans with all units running as a system simultaneously under normal operation. Sequence shall include switching to economizer operation. Provide results for both normal occupancy and unoccupied modes and economizer mode. Where applicable balance AHUs and VAVs at full flow and also record readings at simulated normal flow with VAVs in minimum position to confirm remote units received adequate air flow.

C. Balance water flow and adjust pumps as required to deliver the specified flows.

D. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
   1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
   2. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
   3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

E. 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.

F. Take and report testing and balancing measurements in inch-pound (IP units).

3.4 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:
   1. Motors.
   2. Pumps.
   3. Fans and ventilators.
   4. Terminal units.
   5. Chillers
   6. Adiabatic Fluid Coolers
   7. Condensing units.
   8. Variable-refrigerant-flow systems.
   9. Energy-recovery units.
   10. Air-handling units.
   11. Unit heaters.
   12. Cabinet Unit Heaters.

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. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' Record drawings 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.

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 unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
   2. 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.
   3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design stati`c pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
   4. Obtain approval from Commissioning Authority 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.
   5. 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.

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.

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, speed, volts, amps, and static profile.
   4. Mark all final settings.
   5. Test system in economizer mode. Verify proper operation and adjust if necessary.
   6. Measure and record all operating data.

7. Record final fan-performance data.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the 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.
   3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
   4. 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.
      c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
      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. 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.
   5. 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 main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
      d. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
   6. 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.
   7. 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.
b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls Contractor.
9. 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, speed, 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 other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and equipment flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' Record drawings piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
   1. Check expansion tank for proper setting.
   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 controllers.
   5. Verify that motor controllers are equipped with properly sized thermal protection.
   6. Check that air has been purged from the system.

D. Measure and record upstream and downstream pressure of each piece of equipment.

E. Measure and record upstream and downstream pressure of pressure-reducing valves.

F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
   1. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design flow.
   1. Measure total water flow.
      a. Position valves for full flow through coils.
      b. Measure flow by main flow meter, if installed.
      c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
   2. Measure pump TDH as follows:

a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gauge heights.
d. 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.
e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.
1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.
1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:
1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.10 PROCEDURES FOR VARIABLE-FLOW 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 pressure-differential sensor(s) is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no flow diversity:
   1. Adjust pumps to deliver total design flow.
      a. Measure total water flow.
         1) Position valves for full flow through coils.
         2) Measure flow by main flow meter, if installed.
         3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
      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 gauge 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 or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.
      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.
   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.
   4. 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.
   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 pressure-differential set point(s).
   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 flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
    c. Mark final settings.

D. For systems with flow diversity:
1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by Architect.
3. Adjust pumps to deliver total design flow.
    a. Measure total water flow.
        1) Position valves for full flow through coils.
        2) Measure flow by main flow meter, if installed.
        3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
    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 gauge 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 or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.
    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 pressure-differential set point(s).
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. Open AHU heating valve to 100% to simulate heating with the ERV failure to confirm system operation.
12. Mark final settings and verify that memory stops have been set.
13. 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, speed, and static profile.
    c. Mark final settings.

3.11 PROCEDURES FOR PRIMARY-SECONDARY-TERTIERY HYDRONIC SYSTEMS

A. Balance the secondary circuit flow first.

B. Balance the tertiary circuits after the secondary circuits are complete.

C. Adjust the primary circuits to maintain loop temperatures.

D. Adjust pumps to deliver total design flow.
1. Measure total water flow.
    a. Position valves for full flow through coils.
    b. Measure flow by main flow meter, if installed.
    c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
    d. Where tertiary pumps serve a partial load in internal installation open the bypass valves at the temporary termination of the loop piping to achieve eventual system flow and head and record data. Then adjust the flow with VFD to match internal partial loads. Use triple duty valve to add head as required to stabilize pumps.
2. Measure pump TDH as follows:
    a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    c. Convert pressure to head and correct for differences in gauge heights.
    d. 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.
    e. With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

E. Adjust flow-measuring devices installed in mains and branches to design water flows.
1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.
4. Measure temperature change in main loops and adjust flow to upper limits to reduce pumping energy.

F. Adjust flow-measuring devices installed at terminals for each space to design water flows.
1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

G. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

H. For systems without pressure-independent valves or flow-measuring devices at terminals:
1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

I. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
3. Mark final settings.

J. Verify that memory stops have been set.

3.12 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.

3.13 PROCEDURES FOR AIR-COOLED CONDENSING UNITS AND HEAT PUMP CONDENSING UNITS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of compressor(s), fan(s), and motors.

3.14 SOUND TESTS

A. After systems are balanced and Substantial Completion, measure, and record sound levels at twenty (20) 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 (L_{eq}).
3. The sound-testing meter must be capable of using one-third 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 unweighted 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 unweighted 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 Noise Criteria (NC) or Room Criteria (RC) worksheet with equipment on and off.

3.15 VIBRATION TESTS

A. After systems are balanced and Substantially Completion, measure and record vibration levels on equipment having motor horsepower equal to or greater than 25.

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 AABC's "National Standards for Total System Balance." Acceptable levels of vibration are normally "smooth" to "good."
   4. Include in General Machinery Vibration Severity Chart, with conditions plotted.

3.16 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.17 PIPE LEAKAGE TESTS

A. Witness the pipe pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.18 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:
1. Verify HVAC 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.

3.19 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. If design value is less than 100 cfm, within 10 cfm.
2. Air Outlets and Inlets: Plus or minus 10 percent. If design value is less than 100 cfm, within 10 cfm. However confirm minimum air flow balance is achieved.
3. Heating-Water Flow Rate: Plus or minus 5 percent If design value is less than 10 gpm, within 10 percent.
4. Chilled-Water Flow Rate: Plus or minus 5 percent. If design value is less than 10 gpm, within 10 percent.
5. Condenser-Water Flow Rate: Plus or minus 5 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.20 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 system-balancing devices. Recommend changes and additions to system-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 biweekly 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.

3.21 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 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. Heating coil, dry-bulb conditions.
    e. Face and bypass damper settings at coils.
    f. Fan drive settings, including settings and percentage of maximum pitch diameter.
    g. Settings for pressure controller(s).

h. Other system operating conditions that affect performance.

16. Test conditions for pump performance forms, including the following:
    a. Variable-frequency controller settings for variable-flow hydronic systems.
    b. Settings for pressure controller(s).
    c. 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 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, 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 speed.
    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 speed.
    d. Inlet and discharge static pressure in inches wg.
    e. For each filter bank, 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. List for each internal component with pressure-drop, static-pressure differential in inches wg.
    j. Outdoor airflow in cfm.
    k. Return airflow in cfm.
    l. Outdoor-air damper position.
    m. Return-air damper position.

F. 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.

G. 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.

H. 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 speed.
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 speed.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

I. 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 fan 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.

J. 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.

K. 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 speed.
      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.

L. Instrument Calibration Reports:
   1. Report Data:
      a. Instrument type and make.
      b. Serial number.
      c. Application.
      d. Dates of use.
      e. Dates of calibration.

3.22 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.

B. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day

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 TAB shall be considered incomplete and shall be rejected.

E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, 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. All changes shall be tracked to show changes made to previous report.
   2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

3.23 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 230593

SECTION 230713 - 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, exposed exhaust between isolation damper and penetration of building exterior.
   6. Outdoor, concealed supply and return.
   7. Outdoor, exposed supply and return.
   8. All outside air duct system
   9. All exhaust system
   10. All ducted system up to the exterior opening.

B. Related Sections:
   1. Section 230716 "HVAC Equipment 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).
   1. For adhesives, indicating VOC content.
   2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
   3. For coatings, indicating VOC content.
   4. For sealants, indicating VOC content.
   5. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.
   6. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   7. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   8. Detail insulation application at elbows, fittings, dampers, specialties, and flanges for each type of insulation.
   9. Detail application of field-applied jackets.

10. Detail application at linkages of control devices.
11. Qualification Data: For qualified Installer.
12. 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.

1.4 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.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General Requirement Division 01 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

C. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

D. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

E. Open containers exposed to natural light shall be completely covered with minimum 6-mill, opaque, fire retardant plastic covering to prevent the insulation material from being damaged due to ultra-violet rays.

1.6 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.

1.7 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.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.

B. Maintain temperature during and after installation for minimum period of 24 hours.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.1 GENERAL:

A. Comply with requirements listed in PART 3 – Schedule.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic tapers, and cement material containers, with appropriate markings applicable testing and inspecting 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. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

D. Products shall contain no asbestos, lead, mercury, or mercury compounds.

E. 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.

F. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

2.2 ACCEPTABLE MANUFACTURERS

A. Insulating Materials:
1. Knauf
2. Johns-Manville
3. Owens-Corning
4. Dow Chemical Comp.
5. Pittsburg-Corning Corp.
6. Specialty Products & Insulation Comp.
7. Roxul, Inc.

B. Accessories Required for Installation:
1. Childers
2. Forster Products
3. Mon-Eco Industries
4. Venture Tape Corp.
5. AGM Industries

2.3 DUCTWORK INSULATING MATERIALS AND ACCESSORIES

A. Typical applications:
1. Concealed ductwork.
2. Ductwork in MERs or in areas subject to damage. (Exposed locations)
3. Ductwork mounted on roofs.
4. Internal duct liner.
5. Ductwork in uninsulated enclosure

B. Type-D1 (Ductwork in concealed areas):
1. Flexible glass fiber blanket; glass fibers bonded with formaldehyde-free resin. Factory laminated reinforced foil/kraft (FRK) vapor facing material, with minimum 2-inch wide stapling and taping flange on one edge.
2. Minimum density: 1.0 lb/ft3 and 1.5 lb.ft3 based on R requirements
3. Maximum conductivity (k): 0.29 Btu-in/hr-ft2- deg F@ 75 deg F meant temperature.
4. Rated maximum service temperature: Not less than 250 deg F.
5. Design selection based on Owens-Corning, SoftR All-Service Duct Wrap.
6. Impaling Anchors: 12 Ga. Galvanized steel, AGM Industries TACTOO Annular-Ring Insul-hangers with TACTOO GPA-72 Adhesive, or AGM Industries Cupped Head Weld Pins.
7. FSK insulation tape: Venture Tape Corp., type 1525CW.
8. Minimum R-Value:
   a. R-6 for interior spaces.
   b. R-12 for interior unconditioned spaces
   c. R-12 for exterior space

d. Provide required thickness to achieve minimum R value.
e. Minimum thickness as noted on schedule or detail.

C. Type-D2 (Exposed ductwork in MER, in any areas subject to damage, or exposed in finished spaces):
1. Rigid or semi-rigid fiberglass board, in compliance with ASTM C612 Type I-A or Type I-B; faced on one side with foil scrim kraft (FSK) or scrim polyethylene (PSK).
2. Minimum density: 3 lb/ft3.
3. Maximum conductivity (k): 0.23 Btu-in/hr-ft2- deg F @ 75 deg F mean temperature.
4. Rated maximum service temperature: Not less than 450 deg F.
5. Design selection based on Owens-Corning, Fiberglass 700 Series Insulations –Type 705 Rigid Board.
6. Impaling Anchors: 12 Ga. Galvanized steel, AGM Industries TACTOO Annular-Ring Insul-hangers with TACTOO GPA-72 Adhesive, or AGM Industries Cupped Head Weld Pins.
7. FSK insulation tape: Venture Tape Corp., type 1525CW.
8. Jacketing:
   a. Pre-molded PVC Jackets: Johns-Mansville, Zeston 2000/300 insulated covers.
   b. Canvas Jacket (Exposed Indoor Use above 6 feet):
      1) UL listed.
      2) Fabric: 6 oz/sq yd, plain weave cotton.
      3) Fire retardant lagging adhesive: Composite of insulation, jacket and lagging adhesive having flame spread index not greater than 25 and smoke developed index not greater than 50 when tested to ASTM E84.
         a) Cilders CP-50A HV2 Chil-Seal Coating.
9. Minimum R-Value:
   a. R-6 for interior spaces.
   b. R-12 for interior unconditioned spaces
   c. R-12 for exterior space or outside air ducts
   d. Provide required thickness to achieve minimum R value.
   e. Minimum thickness as noted on schedule

D. Type – D3 (Roof-mounted ductwork or manufactured pre-insulated duct work):
1. Rigid, unfaced, closed cell polyisocyanurate foam insulating board.
2. Minimum density: 6 lb/ft3.
3. Maximum conductivity (k): 0.19 Btu-in/hr-ft2- deg F @ 75 deg F mean temperature.
4. Rated service temperature range: -297 deg F to +300 deg F.
5. Design selection base on ITW Insulation Systems, TRYMER 2000 Rigid Board.
6. Impaling Anchors: 12 Ga. Galvanized steel, AGM Industries TACTOO Annular-Ring Insul-hangers with TACTOO GPA-72 Adhesive, or AGM Industries Cupped Head Weld Pins.
7. Jacketing:
   a. Venture Tape Corp., VentureClad 1577CW self-adhesive, 5-ply embossed aluminum, high performance weather jacketing with integral vapor barrier.
   b. Childers Metal Jacketing System, .032 inch thick aluminum with integrally bonded moisture barrier over entire surface.
8. Minimum R-Value:
   a. R-12 for exterior space
   b. Provide required thickness to achieve minimum R value.
   c. Minimum thickness as noted on schedule

2.4 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with 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.

2.5 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.

2.6 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. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   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. Aeroflex USA.
      b. Armacell LLC.
      c. K-Flex USA.
   2. Verify adhesives have a VOC content of 50 g/L or less.
   3. 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."

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   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. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.

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).
3. 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."

D. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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).
3. 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."

E. PVC Jacket Adhesive: Compatible with PVC jacket.
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. Johns Manville; a Berkshire Hathaway company.
b. P.I.C. Plastics, Inc.
c. 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).
3. 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."

2.7 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.
1. VOC Content: 300 g/L or less.
2. Low-Emitting Materials: Verify mastic coatings comply 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."

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

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. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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: 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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: 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.

2.8 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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. 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."
   4. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
   5. Service Temperature Range: 0 to plus 180 deg F.
   6. Color: White.

2.9 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
   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. 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, elastomeric 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.
   7. Verify sealant 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."

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
   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. Childers Brand; H. B. Fuller Construction Products.
   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. Verify sealant has a VOC content of 420 g/L or less.

7. Verify sealant 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."

2.10 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.

2.11 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Foster Brand; H. B. Fuller Construction Products.
      b. Vimasco Corporation.

2.12 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Alpha Associates, Inc.

2.13 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Johns Manville; a Berkshire Hathaway company.
      b. Proto Corporation.
      c. Speedline Corporation.
   2. Adhesive: As recommended by jacket material manufacturer.
   3. Color: White.

D. Metal Jacket:
   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. 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 or 2.5-mil-thick polysurlyn.
   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 or 2.5-mil-thick polysurlyn.

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. 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. Polyguard Products, Inc.

2.14 TAPES

A. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Avery Dennison Corporation, Specialty Tapes Division.
   b. Ideal Tape Co., Inc., an American Biltrite Company.
   c. Knauf Insulation.
   d. 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.

B. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
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. Avery Dennison Corporation, Specialty Tapes Division.
   b. Compac Corporation.
   c. Knauf Insulation.
   d. 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.

2.15 SECUREMENTS

A. Bands:
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. 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, 3/4 inch wide with wing seal or closed seal.
3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      1) AGM Industries, Inc.
      2) Hardcast; a Carlisle Company.
      3) Midwest Fasteners, Inc.
      4) 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      1) AGM Industries, Inc.
      2) Hardcast; a Carlisle Company.
      3) Midwest Fasteners, Inc.
      4) 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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: Stainless 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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: Stainless 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, stainless-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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      1) AGM Industries, Inc.
      2) Hardcast; a Carlisle Company.
      3) Midwest Fasteners, Inc.
      4) 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. C & F Wire.

2.16 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 GENERAL REQUIREMENTS

A. Ductwork Insulation
   1. The duct insulation thickness shall meet the requirements identified in the 2020 Energy Conservation Construction Code of New York State (with Supplement).
   2. The Code required insulation thickness shall be based upon the installed thermal resistance.
   3. In general, all exposed ductwork (e.g., in mechanical equipment rooms) shall be provided with a glass fiber, board type insulation with aluminum jacket and vapor barrier.

3.2 EXAMINATION

A. Verify ductwork has been tested before applying insulation materials.

B. Verify surfaces are clean and dry, with foreign material removed.

C. 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.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Duct Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

C. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

D. 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 thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. 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 with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

E. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

F. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.4 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.
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.

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 4 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.

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.

P. 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.

Q. 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.
   2. For PVC elbows and fittings covers – Tape ends of fitting covers to the insulation jacket.

R. 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.

3.5 PENETRATIONS

A. 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.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. 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."

D. 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."

3.6 ABATEMENT

A. For ductwork, where insulation was removed as part of an abatement projects and the ductwork, piping or equipment is to remain, these items shall be reinsulated to meet the requirements as noted under this section for the associated systems.

3.7 MINIMUM REQUIREMENTS

A. R-Values shall comply with the 2020 Energy Conservation Construction Code of New York State section c403.11
   1. Duct and plenum insulation and sealing.
      a. All supply and return air ducts and plenums shall be insulated with a minimum of R-6 insulation.
      b. When located in unconditioned spaces and with a minimum of R-12 insulation when located outside the building.
   2. When located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by a minimum of R-12 insulation.
   3. Exceptions:
      a. When located within equipment.
      b. When the design temperature difference between the interior and exterior of the duct or plenum does not exceed 15°F.
   4. All joints, longitudinal and transverse seams, and connections in ductwork, shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes. Tapes and mastics used to seal ductwork shall be listed and labeled in accordance with UL 181A or UL 181B. Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened. Unlisted duct tape is not permitted as a sealant on any metal ducts.

B. Ductwork Exposed in in MER, in any areas subject to damage, or exposed in finished spaces:
   1. Finish with canvas jacket sized for finish painting.
      a. All exposed ductwork in finished spaces
      b. 10’-0” and below in MER.
   2. Finish with foil face jacket
      a. Above 10’-0” in MER

C. Blanket Insulation Installation on Ducts and Plenums (TYPE – D1):
   1. 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 12 inches o.c. each way and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing. Installation shall prevent insulation from sagging.
      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.
   2. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
   3. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

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.

D. Board Insulation Installation on Ducts and Plenums (TYPE – D2):
1. Secure with adhesive and insulation pins.
2. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
3. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
4. 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.
5. 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.

6. 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.
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.
8. Installation of Glass-Clos Jacketing: Install directly over bare insulation or insulation with factory-applied jackets.
   a. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   b. Embed glass cloth between two 0.062-inch thick coats of lagging adhesive.
   c. Completely encapsulate insulation with coating, leaving no exposed insulation.

E. Outdoor Installation Application (Type – D3):
1. Insulation boards shall be applied using mechanical fasteners such as weld pins or stick clips. Fasteners shall be located not less than 3" from each edge or corner of the board. Pin spacing along the duct should be no greater than 12" on centers. Additional pins or clips may be required to hold the insulation tightly against the surface where cross breaking is used for stiffening. Weld pin lengths must be selected to insure tight fit but avoid "oil canning". Use faced material on outer layer only in multiple layer applications. Cover pins and clips with vapor sealing pressure-sensitive patches matching insulation facing. Rub hard with a nylon sealing tool to ensure a tight bond and a vapor seal.
2. Seal all insulation joints with 3-inch-wide pressure sensitive joint sealing tape to match the insulation facing venture FSK tape; or approved equal.
3. Installation of jacketing:
   a. Ensure that all surfaces are dry, and that all dust, dirt, oil and/or lubricant have been cleaned from the surface of the insulation to be covered.
   b. All insulation should be taped securely, and all adhesives should be “wetted out” to the substrate surfaces.
   c. Jacket 0.032 aluminum
      1) Cover insulated piping with .032-inch thick Childers aluminum jacketing system per manufacturer’s instructions, with seams located on bottom side of horizontal piping and on the concealed side of vertical piping.
      2) Overlap all seams by minimum 2-inches and apply non-hardening vapor barrier sealant (ECO-Joint No.44-05). Apply ½-inch wide stainless steel strapping and stainless steel seals around jacket material as required.
      3) Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass mesh reinforced vapor barrier cement.
   d. Jacket VentureClad jacketing
      1) Follow manufacturer’s instructions. On straight pipe, cut VentureClad jacketing to the desired length (pipe circumference) plus an additional overlap of 3-inches. For outdoor installations, locate the longitudinal seam at either the 2 o’clock or 10 o’clock position. For indoor applications, locate the seam to minimize visibility. Apply the next piece allowing a 3-inch overlap onto the previous section.

2) On bends and elbow configurations, pre-cover the pipe insulation with VentureClad jacketing. Cut out the required shapes to cover the segments of the bends and elbows and apply. Seal all joints with two wraps of VentureClad #1578-CW Tape, wrapping around the pipe 4-inches from the butt strip joint overlapping the tape 3-inches.
3) Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Install prefabricated metal covers over fittings, joints, and valves. Seal all joints with two wraps of VentureClad #1578 CW Tape, wrapping around the pipe 4-inches from the butt strip joint overlapping the tape 3-inches.

3.8 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. 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.

3.9 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, for 50 percent coverage of duct and plenum surfaces.
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, for 50 percent coverage of duct and plenum surfaces.
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.

3.10 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, 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.

3.11 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. 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 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.

3.13 DUCT INSULATION SCHEDULE, GENERAL

A. Interior Plenums, Interior Ductwork, And Outdoor Ductwork Requiring Insulation:
1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed outdoor air or supply air from energy recovery ventilator.
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.
7. Outdoor, concealed supply and return.

B. Items Not Requiring Insulation:
1. Indoor, exposed supply, return, and exhaust air in conditioned space.
2. Manufactured insulated ductwork.
3. Fibrous-glass ducts.
4. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
5. Factory-insulated flexible ducts.
6. Factory-insulated plenums and casings.
7. Flexible connectors.
8. Vibration-control devices.
9. Factory-insulated access panels and doors.

3.14 DUCT INSULATION SCHEDULE –Check Thickness with 2020 ECCCNYS C403.11.1

A. Indoor Application:

SERVICE	TYPE	INTERIOR THICKNESS INCHES	EXTERIOR UN-CONDITIONED SPACE THICKNESS - INCHES
Exhaust Duct (2)	D1 or D2	0	1.0**
Supply Duct To VAV	D1 or D2	1.0*	2.5**
Supply Duct After VAV	D1 or D2	1.5*	N/A

Return Duct	D1 or D2	0	2.5**
Outside Air Duct interior	D1 or D2	0	2.5**
Ductwork to ERU – Exhaust (2)	D1 or D2	0	2.5**
Ductwork from ERU - Supply	D1 or D2	1.5*	2.5**
Outside Air – In Shafts and unconditional areas	D3	N/A	3.0**

1. Unless noted elsewhere
2. Exhaust systems – within 20'-0" of building exterior discharge (including MER)
3. Jacketing Concealed spaces Aluminum foil jacket
4. Jacketing Exposed: Canvas
5. Do not insulate existing, concealed ductwork
6. Coordinate minimum insulation requirement and comply with 2020 NYSECC C403.11

* Minimum insulation thickness shall provide an R-6 insulation conditioned space

** Minimum insulation thickness shall provide an R-12 insulation in Shafts/unconditional space

*** where manufactured greased duct installed

**** Provide thickness and or layer wrap of ductwork to achieve 2-hr rating.

B. Outdoor Application:

SERVICE	TYPE	THICKNESS - INCHES
Supply Duct	D3	3.0**
Return Duct	D3	3.0**
Exhaust Duct	D3	3.0**
Ductwork to ERU	D3	3.0**

1. Unless noted elsewhere
2. Exterior spaces with Venture-Clad jacketing
3. Premanufactured exterior insulation ductwork shall have a minimum R-12. Field applied insulation not required
4. Coordinate minimum insulation requirement and comply with 2020 NYSECC C403.11

** Minimum insulation thickness shall provide an R-12 insulation

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ECC403.11 Construction of HVAC system elements (Mandatory). Ducts, plenums, piping, and other elements that are part of an HVAC system shall be constructed and insulated in accordance with Sections ECC403.11.1 through ECC403.11.3.1.

ECC403.11.1 Duct and plenum insulation and sealing (Mandatory). Supply and return air ducts and plenums shall be insulated with not less than R-6 insulation where located in unconditioned spaces and where located outside the building with not less than R-8 insulation in *Climate Zones* 1 through 4 and not less than R-12 insulation in *Climate Zones* 5 through 8. Where located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by not less than R-8 insulation in *Climate Zones* 1 through 4 and not less than R-12 insulation in *Climate Zones* 5 through 8.

Exceptions:

1. Where located within equipment.

2. Where the design temperature difference between the interior and exterior of the duct or plenum is not greater than 15°F (8°C).

Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with Section MC603.9 of the *Mechanical Code of New York State*.

ECC403.11.2 Duct construction (Mandatory). Ductwork shall be constructed and erected in accordance with the *Mechanical Code of New York State*.

ECC403.11.2.1 Low-pressure duct systems (Mandatory). Longitudinal and transverse joints, seams and connections of supply and return ducts operating at a static pressure less than or equal to 2 inches water gauge (w.g.) (498 Pa) shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer's instructions. Pres-

sure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *Mechanical Code of New York State*.

Exception: Locking-type longitudinal joints and seams, other than the snap-lock and button-lock types, need not be sealed as specified in this section.

ECC403.11.2.2 Medium-pressure duct systems (Mandatory). Ducts and plenums designed to operate at a static pressure greater than 2 inches water gauge (w.g.) (498 Pa) but less than 3 inches w.g. (747 Pa) shall be insulated and sealed in accordance with Section ECC403.11.1. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *Mechanical Code of New York State*.

ECC403.11.2.3 High-pressure duct systems (Mandatory). Ducts and plenums designed to operate at static pressures equal to or greater than 3 inches water gauge (747 Pa) shall be insulated and sealed in accordance with Section ECC403.11.1. In addition, ducts and plenums shall be leak tested in accordance with the SMACNA HVAC Air Duct Leakage Test Manual and shown to have a rate of air leakage (CL) less than or equal to 4.0 as determined in accordance with Equation 4-8.

$CL = F/P^{0.65}$ **(Equation 4-8)**

where:

F = The measured leakage rate in cfm per 100 square feet of duct surface.

P = The static pressure of the test.

Documentation shall be furnished by the designer demonstrating that representative sections totaling not less than 25 percent of the duct area have been tested and that all tested sections comply with the requirements of this section.

END OF SECTION 230713

SECTION 230716 - 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. Section includes insulating HVAC equipment that is not factory insulated.

B. 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. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
   1. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
   2. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
   3. Qualification Data: For qualified Installer.
   4. 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.

1.4 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 in accordance with 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.

C. Insulation Installed Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General Requirement Division 01 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

C. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

D. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

E. Open containers exposed to natural light shall be completely covered with minimum 6-mill, opaque, fire retardant plastic covering to prevent the insulation material from being damaged due to ultra-violet rays.

1.6 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.

1.7 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.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.

B. Maintain temperature during and after installation for minimum period of 24 hours.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.1 GENERAL:

A. Comply with requirements listed in PART 3 – Schedule.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic tapers, and cement material containers, with appropriate markings applicable testing and inspecting 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. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

D. Products shall contain no asbestos, lead, mercury, or mercury compounds.

E. 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.

F. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

2.2 ACCEPTABLE MANUFACTURERS

A. Insulating Materials:
   1. Knauf
   2. Johns-Manville
   3. Owens-Corning
   4. Dow Chemical Comp.
   5. Pittsburg-Corning Corp.
   6. Specialty Products & Insulation Comp.
   7. Roxul, Inc.

B. Accessories Required for Installation:
   1. Childers
   2. Forster Products
   3. Mon-Eco Industries
   4. Venture Tape Corp.
   5. AGM Industries

2.3 EQUIPMENT INSULATING MATERIALS AND ACCESSORIES

A. Typical applications:

1. Chillers.
2. Pumps.
3. Hydronic Equipment.
4. Heat exchangers.
5. Expansion tanks
6. Air separators

B. Type E-1 Flexible Foam Insulation (Applications below ambient to 120 deg F):
   1. Elastomeric tubular type, smooth-surfaced closed cell foam, in accordance with ASTM C534, Type II - Sheet Grade I.
   2. Service temperature range: -290 deg F to +120 deg F.
   3. Maximum conductivity (k): 0.27 Btu-in/hr-ft2- deg F @ 75 deg F mean temperature in accordance with ASTM C518.
   4. Water vapor permeability: 0.08 perm-inch.
   5. Minimum density: 3.0 lb/ft3 per ASTM D1622 or ASTM D1667.
   6. Adhesive shall be the insulation manufacturer's recommended contact adhesive.
   7. Jacketing:
      a. Pre-molded PVC Jackets: Johns-Mansville, Zeston 2000/300 insulated valve and fitting covers.
      b. Canvas Jacket (Exposed Indoor Use):
         1) UL listed.
         2) Fabric: 6 oz/sq yd, plain weave cotton.
         3) Fire retardant lagging adhesive: Composite of insulation, jacket and lagging adhesive having flame spread index not greater than 25 and smoke developed index not greater than 50 when tested to ASTM E84.
            a) Cilders CP-50A HV2 Chil-Seal Coating.
   8. Insulation finish (paint) shall be the insulation manufacturer's recommended finish.

C. Type E-2 Semi-rigid Glass Fiber Board (Applications from 120 deg -850 deg F):
   1. Semi-rigid board, mineral or glass fibers bonded with a thermosetting resin, in compliance with ASTM C612 Type II.
   2. For service temperatures up to 850 deg F.
   3. Minimum density: 3.0 lb/ft3.
   4. Maximum conductivity (k): 0.28 Btu-in/hr-ft2- deg F @ 200 deg F mean temperature to 0.51 @ 500 deg F mean temperature.
   5. Moisture Absorption: Less than 0.1%.
   6. Design selection based on Johns-Manville 1000 Series Spin-Glas.
   7. Hi-temperature Adhesive:
   8. Jacketing:
      a. Pre-molded PVC Jackets: Johns-Mansville, Zeston 2000/300 insulated valve and fitting covers.
      b. Canvas Jacket (Exposed Indoor Use):
         1) UL listed.
         2) Fabric: 6 oz/sq yd, plain weave cotton.
         3) Fire retardant lagging adhesive: Composite of insulation, jacket and lagging adhesive having flame spread index not greater than 25 and smoke developed index not greater than 50 when tested to ASTM E84.
            a) Cilders CP-50A_HV2 Chil-Seal Coating.
      c. Jacketing: Asbestos free glass fiber cloth, open mesh; Newtex Industries, Zetex 600.

2.4 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with 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.

2.5 INSULATION MATERIALS

A. Comply with requirements in "Breeching Insulation Schedule," "Indoor Equipment Insulation Schedule," and "Outdoor, Aboveground Equipment 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 in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

2.6 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C195.
   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. Ramco Insulation, Inc.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
   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. Ramco Insulation, Inc.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.
   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. Ramco Insulation, Inc.

2.7 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. 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. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
      c. Vimasco Corporation.
   2. Adhesive: As recommended by calcium silicate manufacturer and with a VOC content of 50 g/L or less.
   3. 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."

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. 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. Foster Brand; H. B. Fuller Construction Products.
   2. Adhesive: As recommended by cellular glass manufacturer and with a VOC content of 80 g/L or less.
   3. 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."

D. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
   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. Aeroflex USA, Inc.
      b. Armacell LLC.
      c. K-Flex USA.
   2. Verify adhesives have a VOC content of 50 g/L or less.
   3. 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."
   4. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
   5. Wet Flash Point: Below 0 deg F
   6. Service Temperature Range: 40 to 200 deg F.
   7. Color: Black.

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   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. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
   2. Adhesive: As recommended by mineral fiber manufacturer and with a VOC content of 80 g/L or less.
   3. 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."

F. FSK and PVDC 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
      c. Mon-Eco Industries, Inc.
   2. Verify adhesives have a VOC content of 50 g/L or less.
   3. 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."

G. PVC Jacket Adhesive: Compatible with PVC jacket.
   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. Dow Consumer Solutions.
      b. P.I.C. Plastics, Inc.
      c. Speedline Corporation.
   2. Adhesive: As recommended by Adhesive - PVC Jacket manufacturer and with a VOC content of 50 g/L or less.
   3. 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."

2.8 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.
   1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.
   2. Verify mastics comply 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."

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor and outdoor use on below-ambient services.
   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. Childers Brand; H. B. Fuller Construction Products.
      b. Knauf Insulation.
      c. Vimasco Corporation.
   2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
   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. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
   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. Childers Brand; H. B. Fuller Construction Products.
      b. Knauf Insulation.
      c. Vimasco Corporation.
   2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
   3. Service Temperature Range: 0 to plus 180 deg F.
   4. Color: White.

2.9 LAGGING ADHESIVES

A. Adhesives shall 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
      c. Vimasco Corporation.
   2. Verify adhesive is as recommended by insulation manufacturer and has a VOC content of 50 g/L or less.
   3. 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."
   4. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
   5. Service Temperature Range: 20 to plus 180 deg F.
   6. Color: White.

2.10 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:
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. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Pittsburgh Corning Corporation.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 58 to plus 176 deg F.
4. Color: White or gray.
5. Verify sealant has a VOC content of 420 g/L or less.
6. Verify sealant 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."

C. FSK and Metal Jacket Flashing Sealants:
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. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Mon-Eco Industries, Inc.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.
5. Verify sealant has a VOC content of 420 g/L or less.
6. Verify sealant 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."

D. ASJ Flashing Sealants and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
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. Childers Brand; H. B. Fuller Construction Products.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.
5. Verify sealant has a VOC content of 420 g/L or less.
6. Verify sealant 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."

2.11 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. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.12 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 4 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering equipment.
   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. 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 equipment.
   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. Foster Brand; H. B. Fuller Construction Products.
      b. Vimasco Corporation.

2.13 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Alpha Associates, Inc.

2.14 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C1136, 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. P.I.C. Plastics, Inc.
   c. Speedline Corporation.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:
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. 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: 3-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.
   d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.
   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 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: 3-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.
   d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.
   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.

2.15 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. 3M.
      b. Ideal Tape Co., Inc., an American Biltrite Company.
      c. Knauf Insulation.
   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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. 3M.
      b. Avery Dennison Corporation, Specialty Tapes Division.
      c. Knauf Insulation.
   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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Ideal Tape Co., Inc., an American Biltrite Company.
   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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. 3M.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Knauf Insulation.
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.

2.16 FASTENERS

A. Provide mechanical fasteners for exterior jacket that is compatible with the jack material as recommended by the jacket manufacturer.

B. Mechanical fasteners and or bands are required for all exterior jacket applications

2.17 SECUREMENTS

A. Bands:
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. ITW Insulation Systems; Illinois Tool Works, Inc.
   b. RPR Products, Inc.
2. Stainless Steel: ASTM A240/A240M, Type 304; 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 is 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; 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   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) AGM Industries, Inc.
      2) Gemco.
      3) Nelson Stud Welding.
2. 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.

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) AGM Industries, Inc.
   2) CL WARD & Family Inc.
   3) Gemco.

3. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      1) AGM Industries, Inc.
      2) Gemco.
      3) 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.
4. 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.

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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. C & F Wire.

2.18 CORNER ANGLES

A. PVC Corner Angles: 30-mils-thick, minimum 1- by 1-inch PVC in accordance with 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 in accordance with 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 in accordance with ASTM A240/A240M, Type 304.

PART 3 - EXECUTION

3.1 GENERAL OMH REQUIREMENTS

A. Equipment Insulation
1. Equipment including but not limited to chiller evaporators, chilled water pumps, heat exchangers, hot water storage tanks, boiler auxiliaries, etc. shall be insulated for thermal and/or personnel safety.

2. When available from the manufacturer, equipment shall be provided with factory applied insulation.
3. High temperature applications such as, high temperature boiler flue piping, etc. shall be insulated with calcium silicate or other material suitable for high temperature applications with similar thermal performance.

3.2 EXAMINATION

A. Verify equipment has been tested before applying insulation materials.

B. Verify surfaces are clean and dry, with foreign material removed.

C. 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.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. 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 thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. 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 of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.4 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, and jackets, of 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 storage, application, and finishing. Replace insulation materials that get wet.

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 attached 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-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 4 inches o.c.
      a. For below-ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, in accordance with 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 25 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 in similar fashion 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.

3.5 ABATEMENT

A. For equipment where insulation was removed as part of an abatement projects and the ductwork, piping or equipment is to remain, these items shall be reinsulated to meet the requirements as noted under this section for the associated systems.

3.6 INSTALLATION OF EQUIPMENT INSULATION

A. INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION – EQUIPMENT (TYPE – E1, TYPE – E2):
1. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
b. 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.
c. Protect exposed corners with secured corner angles.
d. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
1) Do not weld anchor pins to ASME-labeled pressure vessels.
2) Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
3) On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
4) Do not overcompress insulation during installation.
5) Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
6) Impale insulation over anchor pins and attach speed washers.
7) 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.
e. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
f. 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 from each end. Install wire or cable between two circumferential girdles 12 inches 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 o.c. Use this network for securing insulation with tie wire or bands.

g. Stagger joints between insulation layers at least 3 inches.
h. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
i. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
j. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

2. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
   a. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
   b. Seal longitudinal seams and end joints.
3. Insulation Installation on Pumps:
   a. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
   b. Fabricate boxes from aluminum or stainless steel, at least 0.050 inch thick.
   c. 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.
4. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   a. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   b. Embed glass cloth between two 0.062-inch thick coats of lagging adhesive.
   c. Completely encapsulate insulation with coating, leaving no exposed insulation.
5. Where FSK jackets are indicated, install as follows:
   a. Draw jacket material smooth and tight.
   b. Install lap or joint strips with same material as jacket.
   c. Secure jacket to insulation with manufacturer's recommended adhesive.
   d. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch wide joint strips at end joints.
   e. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
6. 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.
   a. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
   b. For PVC elbows and fittings covers – Tape ends of fitting covers to the insulation jacket.

7. 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.
8. Where PVDC jackets are indicated, install as follows:
   a. 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. 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.
   b. 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

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. 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.

3.8 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.

3.9 FINISHES

A. Equipment 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.

3.10 FIELD QUALITY CONTROL

A. Owner will 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 "Indoor Equipment Insulation Schedule" and "Outdoor, Aboveground Equipment Insulation Schedule? articles. For large equipment, remove only a portion adequate to determine compliance.

D. All insulation applications will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.11 EQUIPMENT INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size shall comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. Acceptable 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 is Contractor's option.

3.12 INDOOR EQUIPMENT INSULATION SCHEDULE

A. Indoor Application:

SERVICE	TYPE	THICKNESS

		INCHES
Chillers	E2	1.0
Chilled Water Pumps	E1	2.0
Condenser Water/Glycol Pumps	E1	0.0
Heating Water Pumps	E1	1.0
Chilled/ Condensing Water Expansion Tank	E1	1.0
Heating Water Expansion Tank	E1	3.0
Chilled/ Condensing Water Air Separator	E1	2.0
Heating Water Air Separator	E1	3.0

1. Comply with requirements in Part 2 and Part 3 listed above
2. Unless noted elsewhere
3. Exposed spaces with Canvas jacket or Venture-Clad jacketing

END OF SECTION 230716

SECTION 230719 - HVAC PIPING INSULATION

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 insulation for HVAC piping systems.

B. Related Requirements:
   1. Section 230713 "Duct Insulation" for duct insulation.
   2. Section 230716 "HVAC Equipment Insulation" for equipment insulation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
   1. For adhesives, mastics, and sealants, indicating VOC content.
   2. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
   3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
      a. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
      b. Detail attachment and covering of heat tracing inside insulation.
      c. Detail insulation application at pipe expansion joints for each type of insulation.
      d. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
      e. Detail removable insulation at piping specialties.
      f. Detail application of field-applied jackets.
      g. Detail application at linkages of control devices.
   4. Qualification Data: For qualified Installer.
   5. 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.

1.4 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 in accordance with 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.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General Requirement Division 01 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

C. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

D. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

E. Open containers exposed to natural light shall be completely covered with minimum 6-mill, opaque, fire retardant plastic covering to prevent the insulation material from being damaged due to ultra-violet rays.

1.6 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.

1.7 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.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.

B. Maintain temperature during and after installation for minimum period of 24 hours.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.1 GENERAL:

A. Comply with requirements listed in PART 3 – Schedule.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic tapers, and cement material containers, with appropriate markings applicable testing and inspecting 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. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

D. Products shall contain no asbestos, lead, mercury, or mercury compounds.

E. 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.

F. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

2.2 ACCEPTABLE MANUFACTURERS

A. Insulating Materials:
   1. Knauf
   2. Johns-Manville
   3. Owens-Corning
   4. Dow Chemical Comp.
   5. Pittsburg-Corning Corp.
   6. Specialty Products & Insulation Comp.
   7. Roxul, Inc.

B. Accessories Required for Installation:
1. Childers
2. Forster Products
3. Mon-Eco Industries
4. Venture Tape Corp.
5. AGM Industries

2.3 PIPING INSULATING MATERIALS AND ACCESSORIES

A. Typical applications:
1. Indoor piping for fluid temperatures up to 250 degrees F.
2. Piping mounted on roofs.
3. Refrigeration and condensate piping.

B. Type-P1 Fiberglass Piping Insulation (Indoor piping 30 – 250 deg F range):
1. Pre-formed, resin-bonded inorganic fiberglass wool insulation in compliance with ASTM C547, Class 1.
2. Rated maximum service temperature: Not less than 250 deg F.
3. Minimum density: 3.0 lb/ft3.
4. Maximum conductivity (k): 0.23 Btu-in/hr-ft2- deg F @ 75 deg F mean temperature to 0.34 @ 300 deg F mean temperature.
5. Integral kraft reinforced foil, all service jacket with double adhesive enclosure on longitudinal seam.
6. Maximum permeance: 0.02 perm.
7. Design selection based on Owens-Corning, Type SSL II – ASJ.
8. Pre-molded valve and fitting insulation: In compliance with ASTM C547, Class 1; minimum density 3.0 lb/ft3; maximum conductivity (k): 0.26 Btu-in/hr-ft2-deg F @ 75 deg F mean temperature.
9. Jacketing:
    a. Pre-molded PVC Jackets: Johns-Mansville, Zeston 2000/300 insulated valve and fitting covers.
    b. Canvas Jacket (Exposed Indoor Use):
        1) UL listed.
        2) Fabric: 6 oz/sq yd, plain weave cotton.
        3) Fire retardant lagging adhesive: Composite of insulation, jacket and lagging adhesive having flame spread index not greater than 25 and smoke developed index not greater than 50 when tested to ASTM E84.
            a) Cilders CP-50A HV2 Chil-Seal Coating.
10. PVC Tape: Johns-Mansville, Z-Tape.
11. Minimum R-Value: R-3 for interior pipe insulation. Provide required thickness to achieve minimum R value. Minimum thickness as noted on schedule.

C. Type P-2 Mineral Wool Piping Insulation (Indoor piping above 250 degrees F to 850 degrees F):
1. Pre-formed, mineral or glass fibers bonded with a thermosetting resin, in compliance with ASTM C547.
2. Type I, Grade A for service temperatures up to 850 deg F.
3. Type II, Grade A for service temperatures up to 1200 deg F.
4. Minimum density: 3.0 lb/ft3.
5. Maximum conductivity (k): 0.43 Btu-in/hr-ft2-deg F @ 350 deg F mean temperature to 1.53 @ 1200 deg F mean temperature.

6. Moisture Absorption: Less than 0.1%.
7. Integral foil scrim kraft (FSK) type facing.
8. Design selection based on Specialty Products & Insulation Company.
9. Pre-molded valve and fitting insulation: In compliance with ASTM C547 Type 1 or Type II.
10. Jacketing:
    a. Childers Metal Jacketing System, .032 inch thick aluminum, stucco embossed finish with integrally bonded moisture barrier over entire surface. Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
    b. Factory-Fabricated Fitting Covers:
        1) Same material and thickness as jacket, smooth finish.
        2) Preformed 2-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.
    c. Provide removable jacket for control valves.

D. Type P-3 Flexible Foam Piping Insulation (Refrigerant and condensate drain piping):
1. Elastomeric tubular type, smooth-surfaced closed cell foam, in accordance with ASTM C534 Grade I.
2. Service temperature range: -290 deg F to +120 deg F.
3. Maximum conductivity (k): 0.26 Btu-in/hr-ft2- deg F @ 75 deg F mean temperature in accordance with ASTM C518.
4. Minimum density: 3.0 lb/ft3.
5. Adhesive shall be the insulation manufacturer's recommended contact adhesive.
6. Insulation finish (paint) shall be the insulation manufacturer's recommended finish.
7. Jacketing:
    a. Pre-molded PVC Jackets: Johns-Mansville, Zeston 2000/300 insulated valve and fitting covers.

E. Type P-3A Flexible Foam Piping Insert for Hangers:
1. Elastomeric tubular type, smooth-surfaced closed cell foam, in accordance with ASTM C534 Grade1.
2. Service temperature range: -290^0 F to $+120^0$F.
3. Maximum conductivity (k): 0.26 Btu-in/hr-ft2-^{0}F @ 75^0F mean temperature in accordance with ASTM C518.
4. Minimum density: 3.0 lb/ft3.
5. Thickness to match thickness of insulation being installed or existing insulation thickness.
6. Integral polyurethane insert bearing surface.
7. Minimum 30-mil thick aluminum or stainless steel exterior covering.
8. One-piece construction with self-adhesive enclosure.
9. Design selection based on Armacell LLC, Armafix Insulation Pipe Hanger.

F. Type P-4 Fiberglass Piping Insulation (Roof-mounted piping 30 deg F – 250 deg F range):
1. Pre-formed, resin-bonded inorganic fiberglass wool insulation in compliance with ASTM C547, Class 1.

2. Rated maximum service temperature: Minimum 850 deg F.
3. Minimum density: 3.0 lb/ft3.
4. Maximum conductivity (k): 0.23 Btu-in/hr-ft2-deg F @ 75 deg F mean temperature to 0.35 @ 300 deg F mean temperature.
5. Integral kraft reinforced foil, all service jacket with double adhesive enclosure on longitudinal seam.
6. Maximum permeance: 0.02 perm.
7. Design selection based on Owens-Corning, Type SSL II – ASJ.
8. Pre-molded valve and fitting insulation: In compliance with ASTM C547, Class 1; minimum density 3.0 lb/ft3; maximum conductivity (k): 0.26 Btu-in/hr-ft2- deg F @ 75 deg F mean temperature.
9. Jacketing: (for interior pipes)
   a. Pre-molded PVC Jackets: Johns-Mansville, Zeston 2000/300 insulated valve and fitting covers.
10. PVC Tape: Johns-Mansville, Z-Tape.
11. Weather Covering: (for exterior pipes exposed to weather)
    a. Venture Tape Corp., VentureClad 1577CW, self-adhesive, 5-ply embossed aluminum, high performance weather covering with integral vapor barrier.
    b. Childers Metal Jacketing System, .032 inch thick aluminum with integrally bonded moisture barrier over entire surface.
12. Minimum R-Value: R-8 for exterior pipe insulation. Provide required thickness to achieve minimum R value. Minimum thickness as noted on schedule.

2.4 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with 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.

2.5 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 into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

2.6 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C195.
   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. Ramco Insulation, Inc.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
   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. Ramco Insulation, Inc.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.
   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. Ramco Insulation, Inc.

2.7 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. Fiberglass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
   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. Foster Brand; H. B. Fuller Construction Products.
   2. Adhesive: As recommended by cellular glass manufacturer and with a VOC content of 80 g/L or less.
   3. 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."

C. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Aeroflex USA.
      b. Armacell LLC.
      c. K-Flex USA.
   2. Adhesive: As recommended by flexible elastomeric and polyolefin manufacturer and with a VOC content of 80 g/L or less.

3. 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."
4. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
5. Wet Flash Point: Below 0 deg F.
6. Service Temperature Range: 40 to 200 deg F.
7. Color: Black.

D. FSK and PVDC 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Mon-Eco Industries, Inc.
2. Verify adhesives have a VOC content of 50 g/L or less.
3. 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."

E. PVC Jacket Adhesive: Compatible with PVC jacket.
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. Johns Manville; a Berkshire Hathaway company.
b. Speedline Corporation.
c. The Dow Chemical Company.
2. Adhesive: As recommended by Adhesive - PVC Jacket manufacturer and with a VOC content of 50 g/L or less.
3. 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."

2.8 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.
1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.
2. Verify mastics comply 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."

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.

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. 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 E96/E96M or ASTM F1249.
3. Service Temperature Range:
   a. Interior:0 to plus 180 deg F
   b. Exterior: 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, Indoor Use: Suitable for indoor use on below-ambient services.
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. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Mon-Eco Industries, Inc.
2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to 180 deg F.
4. Color: White.

D. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.
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. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range:
   a. Interior:0 to plus 180 deg F
   b. Exterior: Minus 20 to plus 180 deg F.

4. Color: White.

2.9 LAGGING ADHESIVES

A. Adhesives shall 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
      c. Vimasco Corporation.
   2. Verify adhesive is as recommended by insulation manufacturer and has a VOC content of 50 g/L or less.
   3. 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."
   4. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
   5. Service Temperature Range:
      a. Interior:0 to plus 180 deg F
      b. Exterior: Minus 20 to plus 180 deg F.
   6. Color: White.

2.10 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:
   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. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
      c. Pittsburgh Corning Corporation.
   2. Permanently flexible, elastomeric sealant.
      a. Service Temperature Range: Minus 150 to plus 250 deg F.
      b. Color: White or gray.
   3. Verify sealant has a VOC content of 420 g/L or less.
   4. Verify sealant 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."

C. FSK and Metal Jacket Flashing Sealants:

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. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Mon-Eco Industries, Inc.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.
5. Verify sealant has a VOC content of 420 g/L or less.
6. Verify sealant 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."

D. ASJ Flashing Sealants and PVDC and PVC Jacket Flashing Sealants:
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. Childers Brand; H. B. Fuller Construction Products.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.
5. Verify sealant has a VOC content of 420 g/L or less.
6. Verify sealant 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."

2.11 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.

2.12 FIELD-APPLIED REINFORCING MESH

A. Woven Glass-Fiber Mesh: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.
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. Childers Brand; H. B. Fuller Construction Products.

B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.
   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. Foster Brand; H. B. Fuller Construction Products.
      b. Vimasco Corporation.

2.13 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Cloth: 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Alpha Associates, Inc.

2.14 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C1136, 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Airex Manufacturing.
      b. Johns Manville; a Berkshire Hathaway company.
      c. P.I.C. Plastics, Inc.
      d. Speedline Corporation.
   2. Adhesive: As recommended by jacket material manufacturer.
   3. Color: White.
   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. Metal Jacket:
   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. 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: 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 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: 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. Underground Direct-Buried Jacket: 125-mil-thick vapor barrier and waterproofing membrane, consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
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. Pittsburgh Corning Corporation.
b. Polyguard Products, Inc.

F. 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 cross-laminated polyethylene film covered with aluminum-foil facing.
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. Polyguard Products, Inc.

G. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested in accordance with ASTM E96/E96M and with a flame-spread index of 10 and a smoke-developed index of 20 when tested in accordance with ASTM E84.
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. ITW Insulation Systems; Illinois Tool Works, Inc.

H. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested in accordance with ASTM E96/E96M and with a flame-spread index of 25 and a smoke-developed index of 50 when tested in accordance with ASTM E84.
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. ITW Insulation Systems; Illinois Tool Works, Inc.

I. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
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. ITW Insulation Systems; Illinois Tool Works, Inc.

2.15 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. 3M Industrial Adhesives and Tapes Division.
b. Ideal Tape Co., Inc., an American Biltrite Company.
c. Knauf Insulation.
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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. 3M Industrial Adhesives and Tapes Division.

b. Avery Dennison Corporation, Specialty Tapes Division.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.
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. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. 3M Industrial Adhesives and Tapes Division.
b. Ideal Tape Co., Inc., an American Biltrite Company.
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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. 3M Industrial Adhesives and Tapes Division.
b. Ideal Tape Co., Inc., an American Biltrite Company.
c. Knauf Insulation.
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. 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. ITW Insulation Systems; Illinois Tool Works, Inc.
2. Width: 3 inches.
3. Film Thickness: 2 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 120 percent.
6. Tensile Strength: 20 psi in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
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. ITW Insulation Systems; Illinois Tool Works, Inc.
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 psi in width.

2.16 FASTENERS

A. Provide mechanical fasteners for exterior jacket that is compatible with the jack material as recommended by the jacket manufacturer.

B. Mechanical fasteners and or bands are required for all exterior jacket applications

2.17 SECUREMENTS

A. Bands:
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. ITW Insulation Systems; Illinois Tool Works, Inc.
b. RPR Products, Inc.
2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing seal or closed seal.
3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick,3/4 inch wide with wing seal or closed seal.
4. Springs: Twin spring set constructed of stainless steel, with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4 inch wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless steel.
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.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Pipe Insulation
1. A protective jacket shall be provided in areas where the insulation may be subjected to damage.
2. The pipe insulation thickness shall meet the requirements identified in the 2020 Energy Conservation Construction Code of New York State for the specific service and associated pipe size.

3. Where required, additional insulation shall be provided to protect piping systems subjected to freezing conditions.

B. Pipe Fitting, Valve, and Flange Insulation
1. Pipe fittings, valves, and flanges shall be insulated with blanket insulation of the same thickness and with the same jacket as the insulation used on the adjoining piping.
2. Valves over 3" in size, strainers, balancing valves, and other pipe line auxiliaries that require periodic service and/or adjustment shall be provided with removable and reusable insulation covers fastened with valve straps. Laced jackets are not acceptable.

C. Piping insulation exposed to the weather shall be provided with a PVC or aluminum jacket. Closed cell elastomeric foam insulation used on refrigerant pipe may be provided with a UV resistant coating, when installed outdoors, in place of a PVC or aluminum jacket.

3.2 EXAMINATION

A. Verify piping has been tested before applying insulation materials.

B. Verify surfaces are clean and dry, with foreign material removed.

C. 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.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. 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 thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. 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 of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.4 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 of 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 storage, application, and finishing. Replace insulation materials that get wet.

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 attached to structure with vapor-barrier mastic.
   3. Install insert materials and 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 4 inches o.c.
      a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, in accordance with 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 25 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 in similar fashion 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.

3.5 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. Comply with requirements in Section 078400 "Firestopping" for firestopping and fire-resistive joint sealers.

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 078400 "Firestopping."

3.6 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, Mechanical Couplings, and Unions:
   1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, 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 that of 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 that 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 that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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 that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
   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 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.

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. 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 that of adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 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.
6. Pipe Exposed in in MER, in any areas subject to damage, or exposed in finished spaces:
    a. Finish with canvas jacket sized for painting
        1) All exposed piping in finished spaces
        2) 10’-0” and below in MER.
    b. Finish with PVC jacket and fitting covers
        1) Above 10’-0” in MER
7. 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.
    a. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
    b. For PVC elbows and fittings covers – Tape ends of fitting covers to the insulation jacket.

3.7 MINIMUM REQUIREMENTS

A. R-Values shall comply with the 2020 Energy Conservation Construction Code of New York State section c403.11

B. Pipes Exposed in in MER, in any areas subject to damage, or exposed in finished spaces:

1. Finish with canvas jacket sized for finish painting.
   a. All exposed piping in finished spaces
   b. 10’-0” and below in MER.
2. Finish with FSK jacket
   a. Above 10’-0” in MER

C. INSTALLATION OF FIBERGLASS INSULATION – PIPING (TYPE - P1):
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   c. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
   d. 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.
2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of Fiberglass block insulation of same thickness as pipe insulation.
   d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.
3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   b. When preformed sections of insulation are not available, install mitered sections of Fiberglass insulation. Secure insulation materials with wire or bands.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed sections of Fiberglass insulation to valve body.
   b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.

D. Installation of Mineral Wool Insulation-Piping (Type-P2):
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   c. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
   d. 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.
2. Insulation Installation on Pipe Flanges:

a. Install preformed pipe insulation to outer diameter of pipe flange.
b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. 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.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   d. Install insulation to flanges as specified for flange insulation application.
5. Field-Applied Jacket Installation:
   a. Where metal jackets are indicated, install with 2-inchoverlap 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. INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION – PIPING (TYPE – P3):
1. 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.
2. Insulation Installation on Pipe Flanges:
   a. Install pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. 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.
   d. 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.
3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install mitered sections of pipe insulation.
   b. 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.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed valve covers manufactured of same material as pipe insulation when available.

b. 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.
c. Install insulation to flanges as specified for flange insulation application.
d. 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.

F. INSTALLATION OF FLEXIBLE ELASTOMERIC PIPE SUPPORT INSULATION– PIPING (TYPE – P3A):
1. Ensure that the pipe surface is clean and dry.
2. Fit the pipe support around the pipe at the required hanger locations. Remove the self-sealing strips and join the edges.
3. Install a standard pipe shield or support bracket around the outer aluminum or stainless steel cover.
4. Wet seal the joins in at both ends of the pipe support insert using Armaflex 520 Adhesive, or the insulation manufacturer recommended adhesive.
5. Seal the butt joints with the pipe insulation on either side of the pipe support insert using Armaflex 520 Adhesive, or the insulation manufacturer recommended adhesive.
6. Install the pipe support hanger. Over-tighten slightly so that the insulation is under slight compression to prevent movement, and so that no weak points occur in the glued seams or butt joints. Use nylon lock nuts on the hanger assembly to prevent loosening of the hanger due to vibration.

G. INSTALLATION FOR ROOF MOUNTED PIPING INSULATION (TYPE – P4):
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   c. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
   d. 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.
2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of Fiberglass block insulation of same thickness as pipe insulation.
   d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.
3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   b. When preformed sections of insulation are not available, install mitered sections of Fiberglass insulation. Secure insulation materials with wire or bands.
4. Insulation Installation on Valves and Pipe Specialties:

a. Install preformed sections of Fiberglass insulation to valve body.
b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
c. Install insulation to flanges as specified for flange insulation application.

5. Installation of jacketing:
   a. Ensure that all surfaces are dry, and that all dust, dirt, oil and/or lubricant have been cleaned from the surface of the insulation to be covered.
   b. All insulation should be taped securely, and all adhesives should be "wetted out" to the substrate surfaces.
   c. Jacket 0.032 aluminum
      1) Cover insulated piping with .032-inch thick Childers aluminum jacketing system per manufacturer's instructions, with seams located on bottom side of horizontal piping and on the concealed side of vertical piping.
      2) Overlap all seams by minimum 2-inches and apply non-hardening vapor barrier sealant (ECO-Joint No.44-05). Apply ½-inch wide stainless steel strapping and stainless steel seals around jacket material as required.
      3) Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass mesh reinforced vapor barrier cement.
   d. Jacket VentureClad jacketing
      1) Follow manufacturer's instructions. On straight pipe, cut VentureClad jacketing to the desired length (pipe circumference) plus an additional overlap of 3-inches. For outdoor installations, locate the longitudinal seam at either the 2 o'clock or 10 o'clock position. For indoor applications, locate the seam to minimize visibility. Apply the next piece allowing a 3-inch overlap onto the previous section.
      2) On bends and elbow configurations, pre-cover the pipe insulation with VentureClad jacketing. Cut out the required shapes to cover the segments of the bends and elbows and apply. Seal all joints with two wraps of VentureClad #1578-CW Tape, wrapping around the pipe 4-inches from the butt strip joint overlapping the tape 3-inches.
      3) Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Install prefabricated metal covers over fittings, joints, and valves. Seal all joints with two wraps of VentureClad #1578 CW Tape, wrapping around the pipe 4-inches from the butt strip joint overlapping the tape 3-inches.

3.8 INSTALLATION OF FIBERGLASS 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 Fiberglass block insulation of same thickness as that of 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 that of 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 Fiberglass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of Fiberglass 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.

3.9 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. 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.

B. 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 that of 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.

C. 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.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as that of 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.

3.10 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 that of 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 that of 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.

3.11 INSTALLATION OF FIELD-APPLIED JACKETS

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 and for horizontal applications, install with 1-inch overlap at longitudinal seams and end joints. 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.

3.12 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. 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.

3.13 FIELD QUALITY CONTROL

A. Owner will engage a qualified testing agency to perform tests and inspections.

B. 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: 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 per phase of straight pipe, three locations per phase of threaded fittings, three locations per phase of welded fittings, three locations per phase of threaded strainers, three locations per phase of welded strainers, three locations per phase of threaded valves, and three locations per phase of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

F. All insulation applications will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.14 PIPING INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size shall comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. 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.

C. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   1. Underground piping.
   2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

D. Minimum pipe insulation shall be as per the below schedule from Table ECC403.11.3 unless more stringent requirements are noted below in section 3.17

3.15 PIPE INSULATION SCHEDULE

A. INDOOR PIPING INSULATION SCHEDULE
   1. Condensate and Equipment Drain Water below 60 Deg F: Type P-3 or P-3A.
   2. Condenser-Water Glycol Supply and Return, 105 Deg F and Below: Type P-1.

3. Chilled-Water Supply and Return, 60 Deg F and Below: Type P-1.
4. Heating-Hot-Water Supply and Return, 250 Deg F and Below: Type P-1.
5. High Temp Hot Water Supply and Return, 250 to 850 Deg F: Type P-2.
6. Refrigerant Suction and Hot-Gas Piping: Type P-3 or P-3A.
7. Refrigerant Suction and Hot-Gas Flexible Tubing: Type P-3 or P-3A.
8. Refrigerant Liquid Piping: Type P-3 or P-3A.
9. Domestic Cold Water – Make-up Water Piping: Type P-1.

B. OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE
1. Condenser-Water & Glycol Supply and Return, 105 Deg F and Above: Type P-4.
2. Chilled-Water Supply and Return, 60 Deg F and Below: Type P-4.
3. Heating-Hot-Water Supply and Return, 250 Deg F and Below: Type P-4.
4. Refrigerant Suction and Hot-Gas Piping: Type P-4.
5. Refrigerant Suction and Hot-Gas Flexible Tubing: Type P-4.
6. Refrigerant Liquid Piping: Type P-4.
7. Domestic Cold Water Piping: Type P-4.

C. Piping system to be insulated include the following:
1. Any system associated with fluids that are mechanical heated and cooled
2. Condenser Water
3. Domestic Cold Water

D. Indoor Application: Refer to section 3.17 below
1. Comply with requirements in Part 2 and Part 3 listed above
2. Unless noted elsewhere
3. Exposed spaces with Canvas jacket or Venture-Clad jacketing
4. Minimum R-Value: R-3 for interior pipe insulation. Provide required thickness to achieve minimum R value. Minimum thickness as noted on schedule.

E. Outdoor Application: Refer to section 3.17 below
1. Comply with requirements in Part 2 and Part 3 listed above
2. Unless noted elsewhere
3. Venture-Clad jacketing for all hydronic piping
4. Refrigerant piping jacket shall be aluminum. or Venture Clad
5. Pre-Engineered piping as specified in section 232113.13
6. Minimum R-Value: R-8 for exterior pipe insulation. Provide required thickness to achieve minimum R value. Minimum thickness as noted on schedule.

3.16 PIPING INSULATION SCHEDULE–Thickness with 2020 ECCCNYS C403.11.3

MINIMUM PIPE INSULATION THICKNESS (in inches)[a, c]

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity Btu · in./(h · ft^2 · °F)[b]	Mean Rating Temperature, °F	< 1	1 to < 1$^1/_2$	1$^1/_2$ to < 4	4 to < 8	≥8
> 350	0.32 – 0.34	250	4.5	5.0	5.0	5.0	5.0
251 – 350	0.29 – 0.32	200	3.0	4.0	4.5	4.5	4.5
201 – 250	0.27 – 0.30	150	2.5	2.5	2.5	3.0	3.0
141 – 200	0.25 – 0.29	125	1.5	1.5	2.0	2.0	2.0
105 – 140	0.21 – 0.28	100	1.0	1.0	1.5	1.5	1.5
40 – 60	0.21 – 0.27	75	0.5	0.5	1.0	1.0	1.0
< 40	0.20 – 0.26	50	0.5	1.0	1.0	1.0	1.5

For SI: 1 inch = 25.4 mm, °C = [(°F) - 32]/1.8.

a. For piping smaller than 11/2 inches and located in partitions within conditioned spaces, reduction of these thicknesses by 1 inch shall be permitted (before thickness adjustment required in footnote b) but not to a thickness less than 1 inch.

b. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

$$T = r\{(1 + t/r)K/k - 1\}$$

where:

T = minimum insulation thickness,

r = actual outside radius of pipe,

t = insulation thickness listed in the table for applicable fluid temperature and pipe size,

K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu · in/h · ft2 · °F) and

k = the upper value of the conductivity range listed in the table for the applicable fluid temperature.

c. For direct-buried heating and hot water system piping, reduction of these thicknesses by $1^1/_2$ inches (38 mm) shall be permitted (before thickness adjustment required in footnote b but not to thicknesses less than 1 inch (25 mm).

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ECC403.11 Construction of HVAC system elements (Mandatory). Ducts, plenums, piping, and other elements that are part of an HVAC system shall be constructed and insulated in accordance with Sections ECC403.11.1 through ECC403.11.3.1.

ECC403.11.3 Piping insulation (Mandatory). Piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table ECC403.11.3.

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.

2. Factory-installed piping within room fan-coils and unit ventilators tested and rated according to AHRI 440 (except that the sampling and variation provisions of Section 6.5 shall not apply) and AHRI 840, respectively.

3. Piping that conveys fluids that have a design operating temperature range between 60°F (15°C) and 105°F (41°C).

4. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.

5. Strainers, control valves, and balancing valves associated with piping 1 inch (25 mm) or less in diameter.

6. Direct buried piping that conveys fluids at or below 60°F (15°C).

ECC403.11.3.1 Protection of piping insulation (Mandatory). Piping insulation exposed to the weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance and wind, and shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall not be permitted.

ECC403.12.1 Heating outside a building. Systems installed to provide heat outside a building shall be radiant systems.

Such heating systems shall be controlled by an occupancy sensing device or a timer switch, so that the system is automatically de-energized when occupants are not present.

ECC403.12.2 Snow-and ice-melt system controls. Snow and ice-melting systems shall include automatic controls configured to shut off the system when the pavement temperature is above 50°F (10°C) and precipitation is not falling, and an automatic or manual control that is configured to shut off when the outdoor temperature is above 40°F (4°C).

E**CC403.12.3 Freeze protection system controls.** Freeze protection systems, such as heat tracing of outdoor piping and heat exchangers, including self-regulating heat tracing, shall include automatic controls configured to shut off the systems when outdoor air temperatures are above 40°F (4°C) or when the conditions of the protected fluid will prevent freezing.

3.17 UNDERGROUND, FIELD-APPLIED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 230719

SECTION 230900 – INSTRUMENTATION AND CONTROL 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 RELATED REQUIREMENTS:

A. Sections noted below have requirements on components as they relate to the Building Management System in addition the requirements discussed in this section
   1. Division 01
      a. General and Special Requirements
      b. Submittal Requirements
      c. Materials and Equipment
   2. Division 23
      a. Common Work Results for HVAC
      b. Variable Frequency Drives
      c. Testing, Adjusting, and Balancing for HVAC
      d. Commissioning of HVAC
      e. Commissioning of Integrated Automation
   3. Division 26
      a. General Electrical Provisions for Electrical Work
      b. Common Work Results for Electrical
      c. Low Voltage Electrical Power Conductors and Cables
      d. Hangers and Supports for Electrical Systems
      e. Raceway and Boxes for Electrical Systems
      f. Identification for Electrical Systems
      g. Wiring Devices
   4. 230923.11 Control Valves
   5. 230923.12 Control Dampers
   6. 230923.23 Pressure Instruments
   7. 230923.27 Temperature Instruments

1.3 SUMMARY

A. This Section includes control equipment and installation for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-furnished controls.

B. The control system shall be extension of the existing Siemens Building Automation System and all controllers and software shall match existing or be the latest version of existing. See Scope of Work for more details

C. All new HVAC equipment shall be controlled, scheduled, trended, alarmed, and monitored by the Trane Ensemble system.

D. The Direct Digital Control (DDC) system shall be UL Listed and Labeled. Electrical standards: Provide electrical products that comply with the following agency approvals:
   1. UL-916: Energy Management Systems for BAS components and ancillary equipment
   2. UL-864: BMS DDC controllers performing smoke damper monitoring shall be UUKL Listed under standard 864.
   3. Fire Alarm system shall perform all Life Safety operations including shutdown of AHU's, EF's, and air handling equipment as per code. BAS shall monitor AHU and EF shutdown signal from Fire Alarm Panel

E. HVAC control systems shall be by a fully distributed, direct digital control (DDC) system with peer to peer architecture and standalone capability.

F. The HVAC control system shall utilize ASHRAE 135 2016 Standard. The communication protocol shall be BACnet.

G. All HVAC&R packaged equipment controls and all final control elements (e.g., valves, damper actuators, sensors, and meters) shall be fully compatible with the BMS manufacturer.

H. All terminal unit control devices shall be electric or electronic with a 4-20mA or 0-10V DC control signal.

I. Electrically operated, line voltage (e.g., 120 volt) control devices are not permitted.

J. Provide a 120 volt plug in uninterrupted power supply for all main controllers.

K. All control valves and dampers shall be equipped with a method to ensure a "fail-safe" position should a power or controller failure occur. In general, valves shall be normally open (NO) for heating and normally closed (NC) for cooling. In general, dampers shall be normally closed (NC) for outdoor air intakes.

L. Wall mounted temperature sensors shall be flush mounted and shall be vandal resistant. The use of return air temperature sensors in high abuse areas shall be reviewed and approved by Owner. Space temperature sensors shall not be located on exterior walls, near lights or where sensing could be affected by heat producing devices. Sensors in non-client areas, such as administration areas, may be standard wall mounted sensors.
   1. Sensors shall be 1000omh thermistor type.
   2. Ducts or mixing boxes equal or greater than 16 square feet shall utilize averaging type sensors unless otherwise specified.

M. BMS contractor shall provide the owner with the necessary hardware and software to modify and create new system graphics. The BMS contractor shall furnish all software licenses necessary for the legal operation of the BMS. Software functions shall include full suite of field engineering tools including graphical programming and applications. The BMS contractor shall provide the Owner with:
   1. All software passwords required to program and make future changes to the system
   2. All software required for all field engineering tools including graphical programming and applications.
   3. All software required to make any program changes anywhere in the system along with scheduling, and trending applications
   4. All software required to program application specific controllers and all field level devices and controllers, excluding existing controllers.
   5. Unlimited update of all software in the BMS.

N. The controls contractor shall have sole responsibility for the entire system including wiring (no shared backbone). All control valves, dampers, and actuators shall be provided by the control system manufacturer.

1.4 ABBREVIATIONS

A. List of Abbreviations
1. AHU: Air Handling Unit.
2. ALN: Automation Level Network
3. ASC: Application Specific Controller
4. BAS: Building Automation System
5. BC: Building Controller
6. BIBB: BACnet Interoperability Building Blocks
7. BMS: Building Management System.
8. CFM: Cubic Feet per Minute.
9. DDC: Direct digital controls
10. FAS: Fire Alarm System.
11. FLN: Floor Level Network
12. FCU: Fan Coil Unit
13. HMI: Human Machine Interface
14. HVAC: Heating, Ventilating and Air Conditioning.
15. I/O: Input/Output
16. IP: Internet Protocol
17. IT: Information Technology
18. LAN: Local area network.
19. LCD: Liquid Crystal Display
20. LED: Light Emitting Diode
21. MER: Mechanical Equipment Room.
22. MLN: Management Level Network
23. MS/TP: Master-slave/token-passing.
24. PC: Personal Computer
25. PID: Proportional Integral Derivative.
26. RAM: Random Access Memory
27. RTD: Resistance Temperature Device
28. TAB: Testing and Balancing
29. UPS: Uninterruptable Power Supply
30. VAV: Variable Air Volume
31. VFD: Variable Frequency Drive.
32. WAN: Wide Area Network.

1.5 DEFINITIONS

A. BACnet: An industry standard data communication protocol for Building Automation and Control Networks. Refer to the latest version of AHSRAE standard 135.

B. BACnet Secure Connect: As an addendum to the BACnet protocol, it is a secure, encrypted datalink layer that is specifically designed to meet the requirements of managed IP infrastructures.

C. Scope Terminology
1. Provide = Furnish equipment, engineer, program and install
2. Furnish = Furnish equipment, engineer and program
3. Mount = securely fasten or pipe
4. Install = mount and wire
5. Wire = wire only

1.6 WORK INCLUDED

A. The BAS Contractor shall provide a complete and operational system that will perform the sequences of operation as described herein.

B. Furnish a complete distributed direct digital control system in accordance with this specification section. This includes all system controllers, logic controllers, and all input/output devices. Items of work included are as follows:
1. Provide a submittal that meets the requirements below for approval.
2. Coordinate installation schedule with the mechanical contractor and general contractor.
3. Provide installation of all panels and devices unless otherwise stated.
4. Provide power for panels and control devices unless otherwise stated.
5. Provide all low voltage control wiring for the DDC system.
6. Provide miscellaneous control wiring for HVAC and related systems regardless of voltage.
7. Provide engineering and technician labor to program and commission software for each system and operator interface. Submit commissioning reports for approval.
8. Participate in commissioning for all equipment that is integrated into the BAS (Refer to Commissioning sections of the equipment or systems in other parts of this specification.)
9. Provide testing, demonstration and training as specified below.
    a. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer.
    b. Desigo CC Migration, Siemens shall furnish and install the following upgrades to the existing Siemens Automation System as listed below. This scope of work shall include software licensing, software system setup, software database modifications, labor, materials, project management, and engineering for the following phases of work.
    c. Desigo CC Software Installation and Graphics Creation, The installation of the Desigo CC software on a server. This involves license planning based on current object database (graphics, physical points, FLN points, trend points, reports, etc. – run a Sibex report).
    d. Desigo CC new graphics for the existing systems. This is an opportunity to clean up existing Apogee graphics that are unused/duplicates/inaccurate. Prepare new graphics for any control panels that will move to the Desigo CC platform.
    e. Migration of Siemens and 3rd party Control Panels, Furnish labor to migrate existing Siemens BLN areas to the Desigo software platform, Furnish labor to migrate existing BACnet primary devices to the Desigo platform.
    f. Remove of Pneumatic Devices, Replaced with Electric controls, it is the intent of this project to convert all remaining Pneumatic Devices to DDC/Electric controls. Any pneumatic controls not specifically called out on contract documents will be addressed with the “Pneumatic Allowance” caried in the project sell price.

1.7 SUBMITTALS

A. Comply with 2020 NYSECC C403 for system controls.

B. Provide submittals for fast track items that need to be approved and released to meet the schedule of the project. Provide submittals for the following items separately upon request:
   1. Valve schedule and product data
   2. Damper schedule and product data
   3. Mounting and wiring diagrams for factory-installed control components
   4. Thermostat locations

C. Provide a complete submittal with all controls system information for approval before construction starts. Include the following:
   1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
   2. Wiring Diagrams: Power, signal, and control wiring. Detail the wiring of the control devices and the panels. Show point-to-point wiring from field devices to the control panel. Show point-to-point wiring of hardwired interlocks. Show a ladder diagram or schematic of wiring internal to the panels, including numbered terminals. Clearly designate wiring that is done at a factory, at a panel shop or in the field.
   3. Details of control panel faces, including sizes, controls, instruments, and labeling.
   4. Schedule of dampers and actuators including size, leakage, and flow characteristics. If dampers are furnished by other, submit a damper actuator schedule coordinating actuator sizes with the damper schedule.
   5. Schedule of valves including leakage and flow characteristics.
   6. Written description of the Sequence of Operations.
   7. Network riser diagram showing wiring types, network protocols, locations of floor penetrations and number of control panels. Label control panels with network addresses and BACnet device instance numbers. Show all routers, switches, hubs and repeaters.
   8. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.
   9. Starter and variable frequency drive wiring details of all automatically controlled motors.
   10. Reduced size floor plan drawings showing locations of control panels, thermostats and any devices mounted in occupied space.
   11. Product Data: Include manufacturer's technical literature for each control device indicated, labeled with setting or adjustable range of control. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Submit a write-up of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.

D. Submit BACnet Protocol Implementation Conformance Statements (PICS) for all direct digital controllers, software and other system components that will communicate on the BAS utilizing BACnet.

E. Submit a description of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.

F. Submit blank field check-out and commissioning test reports, customized for each panel or system, which will be filled out by the technician during start-up.

G. Variance letter: Submit a letter detailing each item in the submission that varies from the contract specification or sequence of operation in any way.

H. After the BAS system is approved for construction, submit sample operator workstation graphics for typical systems for approval. Print and submit the graphics that the operator will use to view the systems, change setpoints, modify parameters and issue manual commands. Programming shall not commence until typical graphics are approved.

I. Computer Graphics
   1. Submit computer graphics of the BMS interface with the user after the approved submittals as noted above has been reviewed and approved and prior to installing on the server.

J. Operation and Maintenance Data: In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
   1. Product data with installation details, maintenance instructions and lists of spare parts for each type of control device.
   2. Keyboard illustrations and step-by-step procedures indexed for each operator function.
   3. Inspection period, cleaning methods, cleaning materials recommended and calibration tolerances.
   4. Calibration records and list of set points.

1.8 RECORD DOCUMENTATION

A. Project Record Documents: Submit electronic copies of record (as-built) documents upon completion of installation. Submittal shall consist of:
   1. Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD compatible files in electronic format.
   2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements in the Control System Demonstration and Acceptance section of this specification.
   3. Operation and Maintenance (O & M) Manual.
      a. As-built versions of the submittal product data.
      b. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
      c. List of recommended spare parts with part numbers and suppliers.
      d. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.
      e. Complete original original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
      f. Licenses, guarantees, and warranty documents for equipment and systems.
   4. Operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. As a minimum include the following:
      a. Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross-reference the system point names.
      b. Description of manual override operation of all control points in system.

c. BMS system manufacturers complete operating manuals.

5. OWNER Requirements
   a. As Built Documentation: After successful completion of the acceptance test and formal commissioning, the design consultant shall provide the Facility with the three copies of the final documentation in both digital and hardcopy.
   b. Final documentation shall be provided in Digital Media, USB in PDF format and paper 11x17 for drawings, 8.5x11 equipment specifications.
   c. All paper documents shall be bound in laminated ring binders with Index tabs.
   d. A table of contents shall be included.
   e. Digital table of contents shall be hyperlinked to the appropriate section.
   f. The AS built documents shall include final completion dates upon acceptance of the BMS system.
   g. The as built final documentation shall include all documentation as specified in all sections of the specifications.
   h. Software and licenses.
   i. Warranties.
   j. Digital image of the server fully commissioned and accepted.
   k. All programming from each individual controller commissioned and accepted.
   l. Commissioning report.
   m. Maintenance Contract.
   n. Operators' manuals.

1.9 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. All work shall be seamless to the operator when completed.

C. All wiring shall be in compliance with NEC.

D. Manufacturer shall warranty system for a minimum of 12 months at time of acceptance.

E. Codes
   1. Perform all wiring in accordance with Division 26, NEC, local codes and Owner's requirements.
   2. 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.
   3. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."
   4. Comply with ASHRAE 135-2010 BACnet: A Data Communication Protocol for Building Automation and Control Networks.
   5. Comply with BACnet Secure Connect Communication: A secure, encrypted datalink layer that is specifically designed to meet the requirements of managed IP infrastructures.
   6. Comply with ASHRAE 90.1-2013 Energy Standard for Buildings Except Low-Rise Residential Buildings.
   7. All equipment shall be UL listed and approved and shall meet with all applicable NFPA standards, including UL 916 - PAZX Energy Management Systems,
      a. Provide written approvals and certifications after installation has been completed.

8. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
9. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-140001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

F. Qualifications
1. Installing contractor shall be in the business of installing and servicing DDC controls for mechanical systems, temperature and ventilation control, environmental control, lighting control, access and security, life safety and energy management as their primary business.
2. Installer Qualifications: An experienced installer who is the authorized representative of the automatic control system manufacturer for both installation and maintenance of controls required for this Project.
3. Engineering, drafting, programming, and graphics generation shall be performed by Siemens qualified engineers and technicians directly employed by the Building Automation System Contractor.
4. Supervision, checkout and commissioning of the system shall be by the local branch engineers and technicians directly employed by the Building Automation System Contractor. They shall perform commissioning and complete testing of the BAS system.

G. Final determination of compliance with these specifications shall rest solely with the Engineers and Owner who will require proof of prior satisfactory performance.

H. For any BAS system and equipment submitted for approval, the BAS contractor shall state what, if any, specific points of system operation differ from these specifications.

I. All portions of the system must be designed, furnished, installed, commissioned, and serviced by manufacturer approved, factory trained employees.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

B. Deliver, store, protect, and handle products to site under provisions of the contract Documents. Coordinate all site delivers with Construction project Manager.

C. Protect products from construction operations, dust, and debris, by storing materials inside, protected from weather in a conditioned space.

1.11 COORDINATION

A. Coordinate IP drops, network connections, user interfaces, firewall, etc. with Owner’s IT representative.

B. Coordinate location of thermostats, humidistats, panels, and other exposed control components with plans and room details before installation.

C. Coordinate equipment with Division 28 "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate equipment with provider of starters and drives to achieve compatibility with motor starter control coils and VFD control wiring.

E. Coordinate scheduling with the mechanical contractor and general contractor. Submit a schedule for approval based upon the installation schedule of the mechanical equipment.

F. Coordinate installation of taps, valves, airflow stations, etc. with the mechanical contractor.

G. Products Furnished but Not Installed Under This Section
   1. Hydronic and Refrigerant Piping accessories:
      a. Control Valves
      b. Temperature Sensor Wells and Sockets
      c. Pressure Sensor Wells and Sockets
      d. Flow Switches
      e. Flow Meters
      f. Differential Pressure Transmitters
   2. Sheet metal accessories
      a. Dampers
      b. Airflow Stations
      c. Terminal Unit Controls

H. Products Installed but Not Furnished Under This Section
   1. Refrigeration Equipment:
      a. Refrigerant Leak Detection System
      b. Proof of flow pressure switches
   2. Rooftop Air Handling Equipment:
      a. Thermostats
      b. Duct Static Pressure Sensors

1.12 WARRANTY

A. Provide warranty per Division 20 Section “General Mechanical Requirements” and as supplemented in this section.

B. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of 12 months from completion of system demonstration.

C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours.

D. During normal building occupied hours, failure of items that are critical for system operation shall be provided within 4 hours of notification from the Owner’s Representative.

E. This warranty shall apply equally to both hardware and software.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM

A. This project shall be comprised of a high-speed Ethernet network utilizing BACnet/IP communications between System Controllers and Workstations. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall utilize BACnet MSTP (RS485) communications.

2.2 SYSTEM DESCRIPTION

A. The Building Automation System (BAS) contractor shall furnish and install a networked system of HVAC controls. The contractor shall incorporate direct digital control (DDC) for central plant equipment, building ventilation equipment, supplemental heating and cooling equipment, and terminal units.

B. The control system for this project shall be an extension of the Owner's existing Siemens Building Automation System and all controllers and software shall match existing or be latest version of existing.

C. Provide networking to new DDC equipment using industry accepted communication standards. System shall utilize BACnet communication according to ANSI/ASHRAE standard 135-2010 for interoperability with smart equipment, for the main IP communication trunk to the BAS Server and for peer-to-peer communication between DDC panels and devices. The system shall not be limited to only standard protocols but shall also be able to integrate to a wide variety of third-party devices and applications via drivers and gateways.

D. Provide standalone controls where called for on the drawings or sequences.

E. The BAS shall be the Siemens APOGEE system as manufactured by Siemens Industry, Inc.

2.3 BUILDING AUTOMATION SYSTEM NETWORK

A. All networked control products provided for this project shall be comprised of an industry standard open protocol internetwork. Communication involving control components (i.e., all types of controllers and operator interfaces) shall conform to ASHRAE 135-2010 BACnet standard. Networks and protocols proprietary to one company or distributed by one company are prohibited.

B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.
   1. Software applications, features, and functionality, including administrative configurations, shall not be separated into several network control engines working together.

C. BAS Server shall be capable of simultaneous direct connection and communication with BACnet/SC, BACnet/IP, OPC and TCP/IP corporate level networks without the use of interposing devices.

D. Any break in Ethernet communication from the server to the controllers on the Primary Network shall result in a notification at the server.

E. Any break in Ethernet communication between the server and standard client workstations on the Primary Network shall result in a notification at each workstation.

F. The network architecture shall consist of three levels of networks:
   1. The Management Level Network (MLN) shall utilize BACnet/IP over Ethernet along with other standardized protocol, such as web services, html, JAVA, SOAP, XML, etc., to transmit data to non-BAS software applications and databases. The BAS Server and Operator Workstations shall reside on this level of the network architecture.
   2. The Automation Level Network (ALN) shall utilize BACnet/IP over Ethernet. It shall connect BACnet Building Controllers to the BAS Server and Operator Workstations. Controllers for central plant equipment and large infrastructure air handlers shall reside on the ALN backbone BACnet/IP network. The building's Ethernet LAN shall be utilized for the ALN backbone and all ALN devices shall be connected to the building's LAN. Coordinate IP drops with Owner.
   3. The Floor Level Network shall utilize BACnet/IP over Ethernet or BACnet MS/TP over RS-485 to connect all of the DDC-controlled terminal heating and cooling equipment on a floor or in a system that are controlled with BACnet Advanced Application Controllers or BACnet Application Specific Controllers. FLN devices are networked to a router that connects to the Automaton Level Network backbone.

G. Provide a router for each RS-485 subnetwork to connect them to the base building backbone level network. The router shall connect BACnet MS/TP subnetworks to BACnet over Ethernet. Routers shall be capable of handling all of the BACnet BIBBs that are listed for the controller that reside on the subnetwork.

H. The Building Level Controllers shall be able to support subnetwork protocols that may be needed depending on the type of equipment or application. Subnetworks shall be limited to :
   1. BACnet MS/TP
   2. Apogee FLN
   3. Modbus

I. BACnet MSTP Setup rules
   1. Addressing for the MSTP devices shall start at 00 and continue sequentially for the number of devices on the subnetwork.
   2. No gaps shall be allowed in the addresses.
   3. Set the MaxMaster property to the highest address of the connected device.
   4. MaxMaster property shall be adjusted when devices are added to the subnetwork.

J. 12Provide all communication media, connectors, repeaters, bridges, switches, and routers necessary for the internetwork.

K. Controllers and software shall be BTL listed at the time of installation.

L. The system shall meet 3peer-to-peer communication services such that the values in any one BACnet Building Controller or BACnet Advanced Application Controller can be read or changed from all other controllers without the need for intermediary devices. The software shall provide transparent transfer of all data, control programs, schedules, trends, and alarms

from any one controller through the internetwork to any other controller, regardless of subnetwork routers.

M. Systems that use variations of BACnet using Point-to-Point (PTP) between controllers, gateways, bridges or networks that are not peer-to-peer are not allowed.

N. Remote Communications: Provide a TCP/IP compatible communication port for connection to the Owner's network for remote communications. Provide coordination with the Owner for addressing and router configuration on both ends of the remote network.

O. The system shall be installed with a 10% spare capacity on each subnetwork for the addition of future controllers.

P. On each floor, wing or major mechanical room provide an Ethernet RJ45 connection that allows connection to the BACnet network. An open port shall always be available and shall not require any part of the network to be disconnected. The location shall be accessible to the base building personnel and not in a location where the tenant can restrict the access.

Q. Distributed Control Requirements:
1. The loss of any one DDC controller shall not affect the operation of other HVAC systems, only for the points connected to the DDC controller.
2. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.
3. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.
4. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller on the network without dependence upon a central processing device. DDC Controllers shall also be able to send alarms to multiple operator workstations without dependence upon a central or intermediate processing device.
5. Operators shall have the ability to make database changes at the central system server while operator workstations are on-line without disrupting other system operations.
6. The DDC control panel shall be mounted in the same mechanical room as the equipment being controlled, or an adjacent utility room.
7. Multiple systems can be programmed on the same controller as long as they are in the same room. Systems on separate floors shall have separate controllers.
8. VAV boxes subnetworks shall be connected to the AHU controller that feeds those boxes. If multiple subnetworks are needed, then the VAV shall be grouped into subnetworks in an orderly method, such as per floor, per wing, etc.
9. Remote sensors shall be wired to the control panel of the equipment it is controlling, not across the network.
10. Signals to remote motor control centers shall be hard wired to the control panel, not across the network.
11. Terminal units shall each have their own controller. Only exceptions are:
    a. Groups of reheat coils
    b. Groups of exhaust fans

2.4 BUILDING AUTOMATION SYSTEM SERVER HARDWARE

A. Owner to provide a PC for the BAS Server database. (existing)

2.5 OPERATOR WORKSTATION HARDWARE

A. Owner to Provide a PC for a BAS operator workstation. (existing)

2.6 BACNET ADVANCED WORKSTATION SOFTWARE

A. Interface Description (Existing)
   1. The software shall provide, as a minimum, the following functionality:
      a. Real-time graphical viewing and control of the BMS environment.
      b. Reporting of both real-time and historical information.
      c. Scheduling and override of building operations.
      d. Collection and analysis of historical data.
      e. Point database editing, storage and downloading of controller databases.
      f. Configuration of and navigation through default and personalized hierarchical "tree" views that include workstation and control system objects.
      g. Event reporting, routing, messaging, and acknowledgment.
      h. Definition and construction of dynamic color graphic displays.
      i. Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
      j. On-screen access to User Documentation, via online help or PDF-format electronic file.
      k. Automatic database backup at the operator interface for database changes initiated at Building Controllers.
         1) Display dynamic trend data graphical plot.
         2) Must be able to run multiple plots simultaneously.
         3) Each plot must be capable of supporting 10 pts/plot minimum.
         4) Must be able to command points from selection on dynamic trend plots.
         5) Must be able to plot real-time data without prior configuration.
         6) Must be able to plot both real-time and historical trend data simultaneously.
      l. Program editing
      m. Transfer trend data to third-party spreadsheet software
      n. Scheduling reports
      o. Operator Activity Log
   2. Operator interface software shall minimize operator training through the use of user-friendly and interactive graphical applications.
   3. Users must be able to build multiple, separate, personalized hierarchical "tree" views that represent the workstation, control systems, geographical facility layouts, and mechanical equipment relationships.
   4. 256-character point identification (names) must be supported to provide clearly descriptive identification.
   5. On-line help must be available.
   6. The user interface shall display relevant information for a selection in multiple panes of a single window without the need for opening multiple overlapping windows on the desktop

7. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a “drag and drop” approach to inter-application navigation.
8. Software navigation shall be user friendly by utilizing “forward & back” capability between screens and embedded links to graphics, documents, drawings, trends, schedules, as well as external documents (.doc, .pdf, .xls, etc.) or web addresses that are related to any selected object.
9. Primary selection of objects in the operator interface software shall be available from user defined hierarchical Views, from graphics, or from events in an Event List.
10. Secondary selection of objects in the operator interface software shall be available from links to any objects or external documents related to the primary selection.
11. Links to information related to any selected objects shall be displayed in a consistent manner and automatically defined based on where an object is used in the system.
12. The operator workstation shall be capable of displaying web pages and common document formats (.doc, .xls, .pdf) within the operator workstation application.
13. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously.
14. System database parameters shall be stored within an object-oriented database.
15. Standard Windows applications shall run simultaneously with the BMS software.
16. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BMS alarms and monitoring information.
17. Provide automatic backup and restore of all Building Controller databases on the workstation hard disk.
18. System configuration, programming, editing, graphics generation shall be performed on-line from the operator workstation software.
19. User shall be able to edit point configuration of any configurable BACnet point that resides in a devices that supports external editing.
20. The software shall also allow the user to configure the alarm management strategy for each point.
21. Users shall have the ability to view the program(s) that is\are currently running in a Building Controller. The display shall mark the program lines with the following: disabled, comment, unresolved, and trace bits.

B. Certifications and Approvals
1. BAS software shall have been tested against the following norms and standards:
    a. BACnet Revision 1.13, certified by BACnet Testing Laboratory as BACnet Advanced Workstation Software (BTL B-AWS)
    b. IT security compliant with the ISA-99/IEC 62443 Security Level: SL1
    c. OPC DA V2.05a and V3.0 Server, certified by the OPC Foundation certification program
    d. UL-listed to UL864 9th edition Standard for Control Units and Accessories (when installed on a UL-approved computer)

C. Client-Server Connectivity
1. Client sessions must be allowed to run on the server and on other devices connected to the server via Intranet, Extranet, or Internet connections.
2. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the owner as required to support remote access features.
3. The following client options must be supported
    a. Installed Client.

1) Software application installed from installation media on to the client machine.
2) Installed client software must be configurable to allow it to run in a Closed Mode such that the BAS software can lock down the client machine and prevent users without permission from minimizing the application or running other Windows applications that might cover the BAS software interface.
3) Communication between the server and Installed Clients must be monitored so that any break in communication between the server and an installed client results in notification at the Server and Installed Client machine
4) Installed client machines communicate directly with the BAS server

b. Web Client.
1) Software that runs in a browser on the client machine as a Full Trust client application.
2) Connected to the BAS software server via Microsoft IIS Server.

c. Windows App.
1) Software application downloaded from the BAS server to run on the client machine like an installed application
2) Application must be automatically updated whenever new apps are available at the server.
3) Connected to the BAS software server via Microsoft IIS Server.

4. Each of the client options shall provide the same functionalities including operation and configuration capabilities.

D. Access Rights and User Privileges
1. Access to any client user session must be password protected.
2. Users shall be able to create local user accounts specific to the application software.
3. Users shall be able to link application user accounts to Active Directory user accounts for consistent management with domain user accounts.
4. Operator-specific password access protection shall be provided to allow the administrator/manager to limit users' workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned username and password.
5. Operator privileges shall follow the operator to any workstation logged onto.
6. The administrator or manager shall be able to further limit operator privileges based on which console an operator is logged on to.
7. The administrator or manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BMS workstation application.

E. Activity Logging
1. The operator interface software shall maintain a log of the actions of each individual operator.
2. The software shall provide an application that allows querying based on object name, operator, action, or time range.
3. The software shall provide the ability to generate reports showing operator activity based on object name, operator, action, or time range.

F. Graphics Application
1. All graphics shall be available with the same look and functionality whether they are displayed at an installed client console or in a browser.

2. User shall be able to add/delete/modify system graphics for floor plan displays and system schematics for each piece of mechanical equipment (including, air handling units, chilled water systems, hot water boiler systems, and room level terminal units) from standard user interface without the need of any external or specialized tools.
3. The software shall include all necessary tools and procedures for the user to create their own graphics.
4. The software shall provide the user the ability to display real-time point values by animated motion or custom picture control visual representation.
5. The software shall provide animation that depicts movement of mechanical equipment, or air or fluid flow.
6. The software shall provide users the ability to depict various positions in relation to assigned point values or ranges.
7. The software shall provide the ability to add custom gauges and charts to graphic pages.
8. The software must include a library of at least 400 standard control application graphics and symbols for visualizing common mechanical systems, including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams, piping, and laboratory symbols.
9. The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.
10. The Graphics application shall be capable of automatically assigning the appropriate symbol for an object (point) selected to be displayed on the graphic based on what the object represents (fan, duct sensor, damper, etc.) when the object is placed on a graphic.
11. The Graphics application shall allow a user to manually override the automatically assigned symbol for an object when a different symbol is desired.
12. The user shall have the ability to add custom symbols to the symbol library.
13. The software shall permit the importing of AutoCAD or scanned pictures for use in graphics.
14. Graphics must be automatically associated to any points or system objects that are rendered on the graphic, so that selection of a system object will allow a user to simply navigate to any associated graphic, without the need for manual association.
15. The software must allow users to command points directly off graphics application.
16. Graphic display shall include the ability to depict real-time point values dynamically with text or animation.
17. Navigation through various graphic screens shall be optionally achieved through a hierarchical "tree" structure
18. Graphics viewing shall include dynamic pan zoom capabilities.
19. Graphics viewing shall include the ability to switch between multiple layers with different information on each layer.
20. Graphics shall include a decluttering capability that allows layers to be programmatically hidden and displayed based on zoom level.
21. Graphics shall be capable of displaying the status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.
22. The software must provide the ability to create dashboard views consisting of gauges and charts that graphically display system and/ or energy performance.

G. System Performance
1. Comply with the following performance requirements:
    a. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 5 seconds.

b. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 5 seconds.
c. Object Command: Reaction time of less than 5 seconds between operator command of a binary object and device reaction.
d. Object Scan: Transmit change of state and change of analog values to control units or workstation within 5 seconds.
e. Alarm Response Time: Annunciate alarm at workstation within 2 seconds. Multiple workstations must receive alarms within five seconds of each other.
f. Program Execution Frequency: Programmable controllers shall execute DDC PI control loops, and scan and update process values and outputs at least once per second.
g. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
    1) Water Temperature: Plus or minus 1 deg F.
    2) Water Flow: Plus or minus 5 percent of full scale.
    3) Water Pressure: Plus or minus 2 percent of full scale.
    4) Space Temperature: Plus or minus 1 deg F.
    5) Ducted Air Temperature: Plus or minus 1 deg F.
    6) Outside Air Temperature: Plus or minus 2 deg F.
    7) Dew Point Temperature: Plus or minus 3 deg F.
    8) Temperature Differential: Plus or minus 0.25 deg F.
    9) Relative Humidity: Plus or minus 2 percent.
    10) Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
    11) Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
    12) Airflow (Terminal): Plus or minus 10 percent of full scale.
    13) Air Pressure (Space): Plus or minus 0.01-inch wg.
    14) Air Pressure (Ducts): Plus or minus 0.1-inch wg.
    15) Carbon Monoxide: Plus or minus 5 percent of reading.
    16) Carbon Dioxide: Plus or minus 50 ppm.
    17) Electrical: Plus or minus 5 percent of reading.

H. Reports
1. The software must allow reports shall be executed on demand.
2. The software must allow reports shall be executed via pre-defined schedule.
3. As a minimum, the system shall allow the user to easily obtain the following types of reports:
    a. A general listing of all or selected points in the network
    b. A status report showing present value and alarm status
    c. List of all points currently in alarm
    d. List of all points currently in override status
    e. List of all disabled points
    f. System diagnostic reports including, list of Building panels on line and communicating, status of all Building terminal unit device points
    g. List of alarm strategy definitions
    h. List of Building Control panels
    i. Point totalization report
    j. Point Trend data listings
    k. Initial Values report
    l. User activity report
    m. Event history reports

I. Scheduling
1. The software shall provide a calendar type format for simplification of time and date scheduling and overrides of building operations.
2. The software shall support the definition of BACnet schedules that are defined at the workstation and are downloaded to Building Controller to ensure time equipment scheduling when PC is off-line, such that the operating software is not required to execute time scheduling. The software must provide the following capabilities for BACnet scheduling capabilities as a minimum:
   a. Fully support all BACnet Schedule, Calendar, and Command objects.
   b. Daily and Weekly schedules
   c. Ability to combine multiple points into a logical Command Groups for ease of scheduling (e.g., all Building 1 lights)
   d. Ability to schedule for a minimum of up to ten (10) years in advance.
3. The software shall support the definition of schedules that are configured and executed to run at the workstation, to support scheduling of workstation software activities and to support field systems that do not include internal scheduling mechanisms. The software must provide the following capabilities for BACnet scheduling capabilities as a minimum:
   a. Schedule predefined reports
   b. Schedule Trend collections
   c. Schedule automated system backups
   d. Schedule commands to be sent to field panels
   e. Daily and weekly schedules
   f. Setting up and executing Holiday schedules
   g. Ability to combine multiple points into a logical Command Groups for ease of scheduling (e.g., all Building 1 lights)
   h. Ability to schedule for a minimum of up to ten (10) years in advance.
4. The software shall support the definition of Apogee Equipment Schedules Objects that are defined at the workstation and are downloaded to Building Controller to ensure time equipment scheduling when PC is off-line, such that the operating software is not required to execute time scheduling The software must provide the following capabilities for BACnet scheduling capabilities as a minimum:
   a. Apogee equipment schedule Zones
   b. Apogee equipment schedule Events
   c. Configuration of Daily, Weekly, Monthly schedules
   d. Configuration of Replacement Days
5. The software shall provide the ability for users to override regular weekly schedules through menu selection, graphical mouse action or function key.
6. The software shall provide a timeline view, showing the results of any number of combined selected workstation and field panel controller schedules for an overview of facility operation.

J. Trending
1. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time.
2. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user definable.
3. Trend data shall be collected and stored on hard disk for future diagnostics and reporting.
4. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of equipment.

5. System shall support trending in the same device as the monitor point or in an external device.
6. The software must support configuration of panels that have a trending level threshold, above which the data will be automatically uploaded to the BMS server to prevent overwriting the data in the field panel. The trending level will be user defined in % of available space (e.g., automatically upload when the trend buffer is at 75% of allocated space).
7. Trend data reports shall be provided to allow the user to view all trended point data.
8. Trend data reports may be customized to include individual points or predefined groups of selected points.
9. The software shall allow the user to view real-time trend data on trend graphical plot displays.
    a. A minimum of ten points may be plotted
    b. A combination of real-time and historical data may be plotted
    c. Dynamic graphs shall continuously update point values
    d. At any time the user may redefine sampling times or range scales for any point
    e. The user may pause the display and take "snapshots" of plot screens to be stored on the workstation disk for future recall and analysis
    f. Exact point values may be viewed on the Trend plot
    g. Trend graphs may be printed
    h. Operator shall be able to command points by selecting them on the trend plot. Operator shall be able to zoom in on a specific time range within a plot.
    i. The Trend Viewer must allow users to configure separate left and right axis for easier differentiation of point values.
    j. The Trend Viewer must allow users to display historical data for the same group of points at different times simultaneously for easy comparison of system behavior over time.

K. Event Management
1. Event Notification shall be presented to each workstation in a tabular format application and shall include the following information for each event: name, value, event time and date, event status, priority, acknowledgement information, and alarm count.
2. Only events for which the logged on user has privileges to view shall be displayed on each workstation.
3. The software shall provide the ability to users to limit the list of events displayed at each workstation (e.g. only show fire events at this workstation, no matter who is logged on)
4. Each event shall have the ability to sound an audible notification based on the category of the event.
5. Event List shall have the ability to list and sort the events based on event status, point name, ascending or descending activation time.
6. Directly from the Event List, the user shall have the ability to acknowledge, silence the event sound, print, or erase each event.
7. The interface shall provide the option to inhibit the erasing of active acknowledged events, until they have returned to normal status.
8. The user shall have the ability to navigate to all information related to a selected point in order to command, launch an associated graphic or trended graphical plot, or run a report on a selected point directly from the Event List.
9. Each event shall have a direct link from the Event List to further user-defined point informational data.
10. The user shall have the ability to also associate real-time electronic annotations or notes to each event.

11. Software shall provide the option to configure detailed operating procedures that guide a user through predetermined standard operating procedures for handling critical events. Users shall be able to log completion of each operating step as it is performed.

L. Remote Notification (RENO)
1. Workstations shall be configured to send out messages to numeric pagers, alphanumeric pagers, SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition.
2. Email notification must support POP3, IMAP, and SMTP with SSL/TSL
3. Communication with external software must be encrypted.
4. There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices which can receive messages from the system.
5. On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.
6. System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.
7. Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.
8. Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.

M. External Data Access
1. The software shall provide the ability to expose configuration properties and real-time values through CSV files, OPC DA, OPC UA, or REST-based Web Services.
2. The software shall provide the ability for external applications to change configuration and real-time values through OPC DA, OPC UA, or REST-based Web Services.
3. The software shall provide the ability for external applications to access historical Trend data through CSV files or REST-based Web Services.
4. External data access must be secured using the level of permissions configured for users and operator workstations.
5. Web service interfaces must allow for exchanging data (object’s values, events and trend series) between workstation and external applications such as facility management systems, enterprise applications, mobile applications or other value-added services.
6. Documentation describing web services interfaces must be included to allow external developers to write applications that leverage the data exchange.

N. Licensing
1. Software licensing must be allowed to be bound to a dongle or to physical PC hardware.
2. User licenses from all client types shall be from a common pool of client licenses. Licenses for installed and browser-based clients shall not be in separate pools.
3. Provide the number of client licenses as called for here or in the Sequence of Operations.

O. Data Security
1. The BAS software must allow that all communication paths between clients and the server are encrypted and protected against replay attacks as well as data manipulation.
2. Any runtime data transfer between the system server and Web Server (IIS) must be allowed to be encrypted by Desigo CC.

3. Communication between any Web Server (IIS) and the Web Clients must be allowed to be encrypted.
4. Passwords must be handled with encrypted storage and transmission
5. The software must support the use of public domain algorithms for cryptographic functions, including AES, DiffieHellmann, RSA, and SHA-2. No self-coded algorithms shall be allowed.
6. All symmetrical encryption must use 256 bit AES or stronger.
7. All asymmetrical encryption must use 2048 bit or stronger.
8. The software must support the use of commercial certificates for securing client-server communications.
9. The software must support the use of self-signed certificates to allow local deployments without the overhead of obtaining commercial certificates.
10. When using self-signed certificates, the owner of the Desigo CC system is responsible for maintaining their validity status, and for manually adding them to and removing them from the list of trusted certificates.
11. The BAS software shall be compatible with the following Virus Scanners:
    a. Kaspersky
    b. Avira
    c. McAfee
    d. Bitdefender
    e. TrendMicro Office Scan

P. Virtualization
1. The BAS software must be compatible with following Virtualization software packages:
    a. VMware®:
        1) Virtualization platform: VSphere 6.0 or higher
        2) Fault-tolerant software: ESXi 6.0b managed by VCenter Server Appliance v6.0.0 or higher
    b. Stratus®:
        1) Virtualization platform: KVM for Linux CentOS v7.0 or higher
        2) Fault-tolerant software: everRun Enterprise 7.2 or higher
        3) Virtualization platform: Citrix XenServer 6.0.2 or higher
        4) Fault-tolerant software: everRun MX 6.2 or higher

Q. Subsystem Connectivity
1. The BAS application software must be capable of connecting simultaneously to multiple control systems and data sources.
2. Interface software shall simultaneously communicate with and share data between multiple Ethernet-connected building level networks.
3. The BAS application software must support the following standard protocols:
    a. BACnet IP (standard Revision 1.13)
    b. OPC (OLE for Process Control) OPC DA 2.05, 3.0
    c. Modbus TCP
    d. SNMP (Agent V1 and V2)
    e. Siemens Apogee P2
    f. Siemens XNET
4. Any break in system controller communication must result in a notification at the server.

R. BACnet
1. The Operator Workstation Software shall be capable of BACnet IP communications.

2. The Operator Workstation Software shall have demonstrated interoperability during at least one BTL Interoperability Workshop.
3. The Operator Workstation Software shall have demonstrated compliance to BTL B-AWS device classification through BTL listing as specified in ANSI/ASHRAE 135 under revision 1.13 or higher.
4. The BAS software shall meet the BACnet device profile of an Advanced Workstation Server (B-AWS) and Operator Workstation (B-OWS) and shall support the following BACnet BIBBs:
    a. Data Sharing
        1) DS-RP-A Data Sharing-ReadProperty-A
        2) DS-RP-B Data Sharing-ReadProperty-B
        3) DS-RPM-A Data Sharing-ReadPropertyMultiple-A
        4) DS-RPM-B Data Sharing-ReadPropertyMultiple-B
        5) DS-WP-A Data Sharing-WriteProperty-A
        6) DS-WP-B Data Sharing-WriteProperty-B
        7) DS-WPM-A Data Sharing-WritePropertyMultiple-A
        8) DS-COV-A Data Sharing-ChangeofValue-A
        9) DS-COVP-A Data Sharing – ChangeofValueProperty-A
        10) DS-V-A Data Sharing - View - A
        11) DS-AV-A Data Sharing - Advanced View - A
        12) DS-M-A Data Sharing - Modify - A
        13) DS-AM-A Data Sharing - Advanced Modify - A
    b. Scheduling
        1) SCHED-VM-A Scheduling-View and Modify-A
        2) SCHED-AVM-A Scheduling-Advanced View and Modify-A
        3) SCHED-WS-A Scheduling-Weekly Schedule-A
    c. Alarm and Event Management
        1) AE-N-A Alarm and Event-Notification-A
        2) AE-ACK-A Alarm and Event-ACK-A
        3) AE-LS-A Alarm and Event-LifeSafety - A
        4) AE-VM-A Alarm and Event Management - View and Modify - A
        5) AE-AVM-A Alarm and Event Management - Advanced View and Modify - A
        6) AE-VN-A Alarm and Event Management - View Notifications - A
        7) AE-AVN-A Alarm and Event Management - Advanced View Notifications - A
    d. Trending
        1) T-V-A Trending-Viewing and Modifying Trends-A
        2) T-ATR-A Trending-Automated Trend Retrieval-A
        3) T-AVM-A Trending-Advanced View and Modify -A
    e. Network Management
        1) NM-CE-A Network Management-Connection Establishment-A
        2) Device Management
        3) DM-DDB-A Device Management-Dynamic Device Binding-A
        4) DM-DDB-B Device Management-Dynamic Device Binding-B
        5) DM-DOB-A Device Management-Dynamic Object Binding-A
        6) DM-DOB-B Device Management-Dynamic Object Binding-B
        7) DM-DCC-A Device Management-DeviceCommunicationControl-A
        8) DM-TM-A Device Management-Text Message-A
        9) DM-MTS-A Device Management-Manual Time Synchronization-A
        10) DM-ATS-A Device Management-Automatic Time Synchronization-A

11) DM-TS-A Device Management-TimeSynchronization-A
12) DM-UTC-A Device Management-UTCTimeSynchronization-A
13) DM-RD-A Device Management-ReinitializeDevice-A
14) DM-BR-A Device Management-Backup and Restore-A
15) DM-LM-A Device Management-List Manipulation-A
16) DM-LM-B Device Management-List Manipulation-B
17) DM-OCD-A Device Management-Object Creation and Deletion-A
18) DM-ANM-A Device Management-Automatic Network Mapping-A
19) DM-ADM-A Device Management-Automatic Device Mapping-A

5. The BAS Server and Workstations shall support the following Data Link Layers:
   a. BACnet IP Annex J
   b. BACnet IP Annex J Foreign Device
   c. ISO 8802-3, Ethernet (Clause 7)
6. The BAS Server and Workstations shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
   a. Calendar – Creatable, Deletable
   b. Command – Creatable, Deletable
   c. Event Enrollment – Creatable, Deletable
   d. Notification Class – Creatable, Deletable
   e. Schedule - Creatable, Deletable
7. The BAS Server and Workstations shall support transmitting and receiving segmented messages.
8. The BAS Server and Workstation shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.

2.7 DIRECT DIGITAL CONTROLLER SOFTWARE

A. Provide a full capability user license to the owner for the operator to be able to see, modify, create, upload, download and save control programs to the DDC controllers.

B. The software program shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer or another controller for execution.

C. The software shall be provided with an interactive HELP function to assist operators with syntax, abbreviations, commands and saving programs.

D. Point naming and communication format:
   1. All points, panels, and programs shall be identified by a 30-character name. All points shall also be identified by a 16-character point descriptor. The same names shall be displayed at both Building Controller and the Operator Interface.
   2. All digital points shall have a consistent, user-defined, two-state status indication with 8 characters minimum (e.g., Summer, Enabled, Disabled, Abnormal).
   3. The Building Controller Software shall be capable of BACnet communications. The BACnet Building Controller (B-BC) shall have demonstrated interoperability during at least one BTL Interoperability Workshop, have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, Annex L.

E. System Security

1. User access shall be secured using individual security passwords and usernames.
2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
3. Building Controllers shall be able to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any Operator Interface or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.
4. User Log On/Log Off attempts shall be recorded.
5. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
6. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the DDC controller software.

F. User Defined Control Applications: The applications software shall program DDC routines to meet the sequences of operations.
1. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/cooling interlock, supply temperature reset, priority load shedding, and power failure restart.
2. The Building Controllers shall have the ability to perform the following pretested control algorithms:
    a. Two position with differential control and time delays
    b. Floating control
    c. Proportional control
    d. Proportional plus integral control
    e. Proportional, integral, plus derivative control
    f. Automatic tuning of control loops
    g. Model-free adaptive control
    h. Start Stop Time Optimization
3. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
4. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.

G. Peer-to-peer access to other DDC controllers
1. It shall be possible to use any actual or virtual point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.
2. Any process shall be able to issue commands to points in any and all other controllers in the system.
3. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of an advanced annunciation feature, such as:
    a. Generate a report
    b. Annunciate an alarm
    c. Issue a text message or email

H. Alarm Management
1. Alarm management shall be provided within the controller software to monitor and direct alarm information to operator devices.
2. Each Building Controller shall perform distributed, independent alarm analysis, minimize network traffic and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
3. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.
4. An Alarm “shelving” feature shall be provided to disable alarms during testing. (Pull the Plug, etc.).
5. Binary Alarms. Each binary alarm object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
6. Analog Alarms. Each analog alarm object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.
7. All alarm shall include the point's user-defined language description and the time and date of occurrence.
8. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print reports, be logged in the event log, generate custom messages, and display graphics.
9. The user shall be able to add a 200-character alarm message to each alarm point to more fully describe the alarm condition or direct operator response. Each Building Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assigned to any number of points in the Controller.
10. Operator-selected alarms shall be capable of initiating a trigger to an advanced annunciation, such as text, email, etc.
11. An alarm history log shall report the start of the alarm condition, acknowledgement by a user and return of the alarm to normal condition.

I. Scheduling:
1. Provide a comprehensive menu driven program to automatically start and stop designated multiple objects or events in the system according to a stored time.
2. Schedules shall reside in the building controller and shall not rely on external processing or network.
3. It shall be possible to define a group of objects as a custom event (i.e., meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.
4. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.
5. The operator shall be able to define the following information:
    a. Time, day
    b. Commands such as on, off, auto, etc.
    c. Time delays between successive commands.
    d. There shall be provisions for manual overriding of each schedule by an authorized operator.
6. It shall be possible to schedule calendar-based events up to one year in advance based on the following:
    a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal

stop, and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.

b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

J. Automatic Daylight Savings Time Switchover. The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

K. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

L. Enthalpy switchover (economizer). The Building Controller Software (BCS) shall control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover setpoint the BCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly change over to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.

M. Control Loop Algorithm

1. Provide a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, setpoint, and weighting parameters shall be accessible from the operator workstation.

N. Adaptive Loop Tuning

1. Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a monthly, seasonal, quarterly, annual period.
2. For Model-Free Adaptive Control loops, evidence of tuned control loop performance shall be provided via graphical plots or trended data logs. Graphical plots shall minimally include depictions of setpoint, process variable (output), and control variable (e.g., temperature). Other parameters that may influence loop control shall also be included in the plot (e.g., fan on/off, mixed-air temp).
3. For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.
    a. In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.
    b. Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

O. Logic programming: Provide a software routine that can build ladder logic to control using many conditional statements.

1. The logic programming syntax shall be able to combine ladder logic with other software features, such as combining status, scheduling, PDL and alarm conditions into one conditional decision.
2. Logic programming shall be able to reference conditions in any other controller in the system.

P. Staggered Start:
1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable in an application and shall not require written scripts or ladder logic.
2. Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

Q. Totalization Features:
1. Run-Time Totalization. Building Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.
2. Consumption totalization. Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.
3. Event totalization. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

R. Data Collection:
1. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.
2. Building Controllers shall store point history data for selected analog and digital inputs and outputs:
3. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.
4. Two methods of collection shall be allowed: either by up to four pre-defined time intervals or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided.
5. Each Building Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.
6. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in third-party personal computer applications.

2.8 BACNET BUILDING CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Building Controller shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

B. Basis of design is Siemens PX Modular and Compact Controllers (PXC).

C. This controller shall have the BTL listing and meet the BACnet device profile of a Building Controller (B-BC) and shall support the following BACnet BIBBs:
   1. Data Sharing
      a. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
      b. Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A,B)
      c. Data Sharing-Write Property- Initiate, Execute (DS-WP-A,B)
      d. Data Sharing-Write Property Multiple- Execute (DS-WPM-B)
      e. Data Sharing-COV- Initiate, Execute (DS-COV-A,B)
      f. Data Sharing-COV-Unsolicited- Initiate, Execute (DS-COVU-A,B)
   2. Scheduling
      a. Scheduling-Internal- Execute (SCHED-I-B)
      b. Scheduling-External- Execute (SCHED-E-B)
   3. Trending
      a. Trending-Viewing and Modifying Trends - Initiate (T-VMT-A)
      b. Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)
      c. Trending-Viewing and Modifying Trends-External- Execute (T-VMT-E-B)
      d. Trending-Automated Trend Retrieval- Execute (T-ATR-B)
   4. Network Management
      a. Network Management-Connection Establishment- Initiate (NM-CE-A)
   5. Alarming
      a. Alarm and Event-Notification- Initiate (AE-N-A)
      b. Alarm and Event-Notification Internal- Execute (AE-N-E-B)
      c. Alarm and Event-Notification External- Execute (AE-N-E-B)
      d. Alarm and Event-ACK- Initiate, Execute (AE-ACK-A,B)
      e. Alarm and Event –Alarm Summary- Execute (AE-ASUM-B)
      f. Alarm and Event –Enrollment Summary- Execute (AE-ESUM-A,B)
      g. Alarm and Event –Information- Initiate, Execute (AE-ESUM-A,B)
   6. Device Management
      a. Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A,B)
      b. Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
      c. Device Management-Device Communication Control- Execute (DM-DCC-B)
      d. Device Management-Private Transfer- Initiate, Execute (DM-PT-A,B)
      e. Device Management-Text Message- Initiate, Execute (DM-TM-A,B)
      f. Device Management-Time Synchronization- Execute (DM-TS-B)
      g. Device Management-Reinitialize Device- Execute (DM-RD-B)
      h. Device Management-Backup and Restore- Execute (DM-RD-B)
      i. Device Management-List Manipulation- Execute (DM-RD-B)
      j. Device Management-Object Creation and Deletion- Execute (DM-OCD-B)
   7. The Building Level Controller shall support the following Data Link Layers:
      a. BACnet IP Annex J
      b. BACnet IP Annex J Foreign Device
      c. MS/TP Master (Claus 9)
   8. The Building Level Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
      a. Calendar – Creatable, Deletable
      b. Command – Creatable, Deletable
      c. Event Enrollment – Creatable, Deletable
      d. Notification Class – Creatable, Deletable

e. Schedule - Creatable, Deletable

9. The Building Level Controller shall support transmitting and receiving segmented messages.
10. The Building Level Controller shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.
11. The Building Level Controller shall have the capability to act as a BACnet router between MS/TP subnetworks and BACnet/IP.

D. This level of controller shall be used for the following types of systems:
1. Chiller plant systems
2. Heating plant systems
3. Cooling Towers
4. Pumping systems
5. VAV air handlers
6. Air handlers over 15,000 cfm
7. Systems with over 24 input/output points
8. Rooftop systems

E. Computing power and memory minimum:
1. A 32 bit, stand alone, multi-tasking, multiuser, real-time 100MHz digital control microprocessor module.
2. Inputs shall be 16-bit minimum analog-to-digital resolution
3. Outputs shall be 10-bit minimum digital-to-analog resolution
4. Memory module (24 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases (see Controllers Software section), including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial up communications.
5. Real time clock and battery
6. Data collection/ Data Trend module sized for 10,000 data samples.
7. Flash Memory Firmware: Each Building Level Control Panel shall support firmware upgrades without the need to replace hardware.

F. Onboard or Modular hardware and connections:
1. Primary Network communication module, if needed for primary network communications.
2. Secondary Network communication module, if needed for secondary network communications.
3. RJ45 port 10/100Mbaud
4. RS485 ports for subnetworks and point expansion
5. Man to Machine Interface port (MMI)
6. USB Port

G. Input and Output Points Hardware
1. Input/output point modules as required including spare capacity.
2. Input/output point modules shall have removable terminal blocks.
3. Monitoring of the status of all hand off auto switches.
4. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.

5. Local status indication for each digital input and output for constant, up to date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
6. Graduated intensity LEDs or analog indication of value for each analog output.

H. Code compliance
1. Approvals and standards: UL916; CE; FCC
2. Provide UL864-UUKL where called for in the sequences of operations.

I. Accessories:
1. Appropriate NEMA rated metal enclosure.
2. Power supplies as required for all associated modules, sensors, actuators, etc.

J. The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. Provide hand/off/auto switch for each digital output, including spares.

K. Each Building Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

L. Panel setup, point definitions and sequencing diagrams shall be backed up on EEPROM memory.

M. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

N. Building Level control panels shall provide at least two serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal communications, operation of permanently connected modems, printers or terminals.

O. Building Level Controllers shall have the capability to serve as a gateway between Modus subnetworks and BACnet objects. Provide software, drives and programming.

P. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587 1980.

Q. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be “future” on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

R. Environment.

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
4. Controller hardware shall be optionally suitable for rooftop environments.

S. Immunity to power and noise.
1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
   a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
   b. Electrostatic Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
   c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
   d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
4. Isolation shall be provided at all Building Controller's AC input terminals to suppress induced voltage transients consistent with:
   a. IEEE Standard 587 1980
   b. UL 864 Supply Line Transients
   c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

2.9 BACNET ADVANCED APPLICATION CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Advanced Application level control panel shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

B. Basis of design is Unitary Equipment Controller (PXCxx-UCM).

C. The Advanced Application Controller Software shall be capable of BACnet communications. The BACnet Advanced Application Controller (B-AAC) shall have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004 or ANSI/ASHRAE 135-2008. Supported BIBBS shall include:
1. Data Sharing
   a. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
   b. Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A,B)
   c. Data Sharing-Write Property- Initiate, Execute (DS-WP-A,B)
   d. Data Sharing-Write Property Multiple- Execute (DS-WPM-B)
   e. Data Sharing-COV- Initiate, Execute (DS-COV-A,B)
2. Scheduling
   a. Scheduling-Internal- Execute (SCHED-I-B)
3. Trending
   a. Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)
   b. Trending-Automated Trend Retrieval- Execute (T-ATR-B)

4. Network Management
   a. Network Management-Connection Establishment- Initiate (NM-CE-A)
5. Alarming
   a. Alarm and Event-Notification Internal- Execute (AE-N-I-B)
   b. Alarm and Event-ACK- Initiate, Execute (AE-ACK-A,B)
   c. Alarm and Event –Enrollment Summary- Execute (AE-ESUM-B)
   d. Alarm and Event –Information- Execute (AE-INFO-B)
6. Device Management
   a. Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A,B)
   b. Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
   c. Device Management-Device Communication Control- Execute (DM-DCC-B)
   d. Device Management-Time Synchronization- Execute (DM-TS-B)
   e. Device Management-Reinitialize Device- Execute (DM-RD-B)
   f. Device Management-Backup and Restore- Execute (DM-BR-B)
   g. Device Management-List Manipulation- Execute (DM-LM-B)
   h. Device Management-Object Creation and Deletion- Execute (DM-OCD-B)
7. The Advanced Application Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
   a. Calendar – Creatable, Deletable
   b. Command – Creatable, Deletable
   c. Event Enrollment – Creatable, Deletable
   d. Notification Class – Creatable, Deletable
   e. Schedule - Creatable, Deletable
8. The Advanced Application Controller shall support transmitting and receiving segmented messages.

D. Communication:
1. BAS Network: The Advanced Application Controller shall support the following Data Link Layers:
   a. MS/TP Master
2. Serial Communication: Temporary use of portable devices shall not interrupt the BAS communication, nor the normal operation of permanently connected printers or terminals.
   a. Provide at least one EIA-232C serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals.
   b. A USB port shall alternatively be available to support local HMI tools connection.

E. Software
1. The software programs specified in this section shall be provided as an integral part of Advanced Application Controllers and shall not be dependent upon any higher level computer or another controller for execution.
2. Advanced Application Controllers shall have the ability to perform energy management routines including but not limited to
   a. scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides
   b. automatic daylight savings time switch over
   c. night setback control
   d. economizer switch over using enthalpy, dry bulb or a combination
   e. peak demand limiting,
   f. temperature-compensated duty cycling

g. heating/cooling interlock
h. supply temperature reset
i. priority load shedding
j. power failure restart

3. The software shall have a routine for automatic tuning of control loops
4. System Security in the Field Panel
   a. User access shall be secured using individual security passwords and usernames.
   b. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
   c. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
   d. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.

F. User Defined Control Applications:
   a. Controllers shall be fully programmable. Controllers shall execute custom, job-specific sequences to automatically perform calculations and special control routines. Factory installed or pre-configured sequences shall only be allowed if they exactly match the sequence specified herein.
   b. Programs shall combine control logic, control loop algorithms, and energy management routines
   c. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.
   d. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual.

G. Adaptive Loop Control.
1. Each AAC controller shall come standard with an Adaptive Control Loop Algorithm
   a. Tuning parameter shall automatically adjust for non-linear applications
2. Model-Free Adaptive (MFA) algorithm
   a. The algorithm shall not require modeling of the non-linear system in order to maintain control at all points of the non-linear load.
   b. The controlled variable, setpoint, and weighting parameters shall be user selectable.
3. Output shall be analog or shall stage a series of outputs.
4. Adaptive Control shall take the place of Proportional, Proportional + Integral, and PID type algorithms for non-linear applications. Adaptive Control routines shall :
   a. Improve response time
   b. Improve System efficiency
   c. Improve Stability
   d. Result in Consistent outputs
   e. Reduce cycling and repositioning
   f. Reduce wear and tear on actuators
5. Adaptive control shall auto-adjust to compensate for
   a. mode changes
   b. load changes
   c. seasonal changes
   d. Heating and cooling changeover
   e. Heating or cooling capacity changes on the primary side
   f. Flow changes on the primary or secondary side

6. Airflow changes across coil
    a. Flow across a heat exchanger
    b. Adaptive control shall auto-adjust to compensate for
    c. Non-linear coils and heat exchangers
    d. Hot water and chilled water reset routines
    e. Water flow reset routines
    f. Duct Static reset routines
7. Auto-Tune PID loops are not acceptable substitutions.
8. If Adaptive Loop Control is not available, then the BAS contractor shall provide re-tuning of the control loops for coils and heat exchangers for each of the following conditions:
    a. Low heating supply water, high heating supply water
    b. Low load on steam coil, high load on steam coil
    c. Chilled water coil, non-dehumidification and condensing
    d. Chilled water coil, low airflow, high airflow, economizer
    e. Dual temperature systems tune for heating and cooling modes
    f. Each of 4 seasons

H. This level of controller shall be used for the following types of systems:
1. Systems with custom sequences that meet all of the criteria below:
2. No primary pumping systems
3. Secondary Pumping systems that are remote from Central Plants
4. Air handlers up to 15,000 cfm
5. Systems up to 20 input/output points
6. Room control sequences that cannot be achieved with an application specific controller
7. BAS Network or Architecture or Sequences do not require the system to be on an IP network
8. No systems that require integration to meters, VFDs or other smart equipment
9. Integration to smart thermostats is allowed

I. Input/Outputs
1. Inputs shall be 16-bit minimum digital resolution
2. Outputs shall be 10-bit minimum digital resolution
3. The following I/O port types shall be available on the controller
    a. Universal Input (software configurable):
        1) Digital Input choices:
            a) Pulse Accumulator
            b) Contact Closure Sensing
            c) Dry Contact/Potential Free inputs only
            d) Digital Input (10 ms settling time)
            e) Counter inputs up to 20 Hz, minimum pulse duration 20 ms (open or closed)
        2) Analog Input Choices:
            a) 0-10 Vdc
            b) 4-20 mA
            c) 1K Ni RTD @ 32°F (Siemens, JCI, DIN Ni 1K)
            d) 1K Pt RTD (375 or 385 alpha) @ 32°F
            e) 10K NTC Type 2 or Type 3 Thermistor
            f) 100K NTC Type 2 Thermistor
        3) Universal Input or Output (software configurable):
            a) All of the above input types

b) Analog Output Types:
0 to 10 Vdc @ 1 mA max

4) Super Universal Input or Output (software configurable):
a) All of the above input types
b) All of the above output types
c) Super digital output type:
0 to 24 Vdc, 22 mA max. (for controlling pilot relay)
d) Super Analog Output Choices:
0 to 20 mA @ 650 Ω max.

4. Provide software configurable I/O ports such that a programmer makes a port either an input or an output

J. Each System Level Control Panel shall, at a minimum, be provided with:
1. Appropriate NEMA rated metal enclosure.
2. A 32 bit, multi-tasking, real-time 100 MHz digital control microprocessor with plug-in, enclosed processors.
3. Each Advanced Application Controller shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, and operator I/O.
4. Real time clock and battery
5. Data collection/ Data Trend module sized for 10,000 data samples.
6. Power supplies as required for all associated modules, sensors, actuators, etc.
7. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
8. Local status indication for each digital input and output for constant, up to date verification of all point conditions without the need for an operator I/O device.
9. Each control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
10. Graduated intensity LEDs or analog indication of value for each analog output.

K. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for the operating system software and firmware.
1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
2. Brownout protection and power recovery circuitry protect the controller board from power fluctuations.
3. Battery backup shall be provided to support the real-time clock for 10 years
4. The program and database information stored SDRAM memory shall be battery backed for a minimum of 30 days and up to 60 days. This eliminates the need for time consuming program and database re-entry in the event of an extended power failure.

L. Database Restore: Each AAC controller shall automatically save the latest programmed database. The controller shall be able to automatically restore a lost or corrupt database without involvement from the operator.

M. Each System Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both

local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

N. Each Control Panel shall support firmware upgrades without the need to replace hardware.

O. System Level control panels shall provide at least two RS 232C serial data communication ports for operation of operator I/O devices such as operator terminals, and additional memory. Control panels shall allow temporary use of portable operator interface devices without interrupting the normal communications.

P. Immunity to noise.
1. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
2. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
   a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
   b. Electrostatic Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
   c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
   d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
3. Isolation shall be provided at all Advanced Application Controller's AC input terminals to suppress induced voltage transients consistent with:
   a. IEEE Standard 587 1980
   b. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

Q. Agency Compliance
1. UL UL916 PAZX (all models)
2. UL916 PAZX7 (all models)
3. FCC Compliance CFR47 Part 15, Subpart B, Class B

R. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be "future" on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

2.10 CONTROL PANELS

A. Controllers in mechanical rooms shall be mounted in NEMA 1 enclosures.

B. Controllers in areas where moisture is a concern shall be mounted in NEMA 12 enclosures.

C. Controllers installed outdoors shall be mounted in NEMA 4X enclosures. Provide heaters where freezing temperatures are normally experienced.

D. Mount on walls at an approved location or provide a free standing rack.

E. Panels shall be constructed of 16 gauge, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with ANSI 61 gray polyester-powder painted finish, UL listed. Provide common keying for all panels.

F. Provide power supplies for control voltage power.

G. Dedicate 1 power supply to the DDC controller. Other devices shall be on a separate power supply, unless the power for the control device is derived from the controller terminations.

H. Power supplies for controllers shall be a transformer with a fuse or circuit breaker. Power supplies for other devices can be plain transformers.

I. All power supplies for 24V low voltage wiring shall be class 2 rated and less than 100VA. If low voltage devices require more amps, then provide multiple power supplies. If a single device requires more amps, then provide a dedicated power supply in a separate enclosure and run a separate, non-class 2 conduit to the device.

J. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator's workstations.

K. All devices in a panel shall be permanently mounted, including network switches, modems, media converters, etc.

L. Provide a pocket to hold documentation.

2.11 SENSORS

A. General
1. Provide mounting hardware for all devices, including actuator linkages, wells, installation kits for insertion devices, wall boxes and fudge plates, brackets, etc.
2. If a special tool is required to mount a device, provide that tool.

B. Terminal Unit Space Thermostats
1. Each controller performing space temperature control shall be provided with a matching room temperature sensor.
   a. Plain Space Temperature Sensors – Wired: Where called for in the sequences or on the drawings, provide sensors with plain covers.
   b. The sensing element for the space temperature sensor shall be thermistor type providing the following.
      1) Element Accuracy: + /- 1.0°F
      2) Operating Range: 55 to 95°F
      3) Set Point Adjustment Range: 55 to 95°F
      4) Calibration Adjustments: None required
      5) Installation: Up to 100 ft. from controller
      6) Auxiliary Communications Port: as required
      7) Local LCD Temperature Display: as required
      8) Setpoint Adjustment Dial as required
      9) Occupancy Override Switch as required
   c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.
2. Digital Display temperature sensor specifications – Wired:

a. As called for in the sequences of operations or on the drawings, provide temperature sensors with digital displays.
b. The sensing element for the space temperature sensor must be IC-based and provide the following.
   1) Digitally communicating with the Application Specific Controller.
   2) Mountable to and fully covering a 2 x 4 electrical junction box without the need for an adapter wall plate.
   3) IC Element Accuracy: +/- 0.9°F
   4) Operating Range: 55 to 95°F
   5) Setpoint Adjustment Range: User limiting, selectable range between 55 and 95°F
   6) Display of temperature setpoint with numerical temperature values
   7) Display of temperature setpoint graphically, with a visual Hotter/Colder setpoint indication
   8) Calibration: Single point, field adjustable at the space sensor to +/- 5°F
   9) Installation: Up to 100 ft. from controller
   10) Auxiliary Communications Port: included
   11) Local OLED Temperature Display: included
   12) Display of Temperature to one decimal place
   13) Temperature Setpoint Adjustment included
   14) Occupancy Override Function included
c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

3. Provide the following options as they are called for in the sequences or on the drawings:
   a. Setpoint Adjustment. The setpoint adjustment function shall allow for modification of the temperature by the building operators. Setpoint adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.
   b. Override Switch. An override button shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator's terminal.
   c. Space Combination Temperature and Humidity Sensors. Each controller performing space temperature control shall be provided with a matching room temperature sensor, which also includes the ability to measure humidity for either monitoring or control purposes. The combination temperature and humidity sensors shall have the same appearance as the space temperature sensors. Humidity elements shall measure relative humidity with a +/- 2% accuracy over the range of 10 to 90% relative humidity. Humidity element shall be an IC (integrated circuit) sensing element. Humidity sensing elements shall be removable and field replaceable if needed.

C. Temperature Sensors
   1. All temperature sensors shall meet the following specifications:

a. Accuracy: Plus or minus 0.2 percent at calibration point.
b. Wire: Twisted, shielded-pair cable.
c. Vibration and corrosion resistant

2. Space temperature sensors shall meet the following specifications:
   a. Platinum RTD with 4-20mA transmitter for major mechanical equipment.
   b. NTC resistance sensor, for DXR controller space sensors.
3. Insertion Elements in Ducts shall meet the following specifications:
   a. Platinum RTD with 4-20mA transmitter
   b. Use where not affected by temperature stratification
   c. The sensor shall reach more than 1/3 the distance from the duct wall
   d. Junction box for wire splices
4. Averaging Elements in Ducts shall meet the following specifications:
   a. Length depended on duct size.
   b. Flexible
   c. Use where prone to temperature stratification, in front of coils, or where ducts are larger than 9 sq. ft.
   d. Junction box for wire splices
5. Insertion Elements for Liquids shall meet the following specifications:
   a. Platinum RTD with 4-20mA transmitter
   b. Threaded mounting with matching well
   c. Brass well with minimum insertion length of 2-1/2 inches for pipes up to 4" diameter
   d. Brass well with insertion length of 6 inches for pipes up to 10" diameter
   e. Junction box for wire splices
6. Outside-Air Sensors Platinum RTD with 4-20mA transmitter:
   a. Watertight enclosure, shielded from direct sunlight
   b. Circulation fan
   c. Watertight conduit fitting

D. Where called for in the sequences of operations, provide the following feature on space sensors and thermostats:
   1. Security Sensors: Stainless-steel cover plate with insulated back and security screws
   2. Space sensors with setpoint adjust: Plain white plastic cover with slide potentiometer to signal a setpoint adjustment to the DDC
   3. Space Sensors with LCD display:
      a. Operator buttons for adjusting setpoints, setting fans speeds and overriding unit to on/off
      b. Graphical LCD icons for signaling heating/cooling mode, fans speed, schedule mode, actual temperature and current setpoint

E. Humidity Sensors shall meet the following specifications:
   1. Bulk polymer sensor element
   2. Accuracy: 2 percent full range with linear output
   3. Room Sensors: With locking cover matching room thermostats, span of 0 to 100 percent relative humidity
   4. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity

F. Air Static Pressure Transmitter shall meet the following specifications:
   1. Non-directional sensor with suitable range for expected input, and temperature compensated.

2. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
3. Output: 4 to 20 mA.
4. Building Static-Pressure Range: 0 to 0.25 inches wg.
5. Duct Static-Pressure Range: 0 to 5 inches wg.

G. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.

H. Equipment operation sensors as follows:
1. Status Inputs for Fans: Current sensors, Veris Industries
2. Status Inputs for Pumps: Current sensors, Veris Industries
3. Status Inputs for direct drive electric motors: Current-sensing relay with current transformers, adjustable and sized for 175 percent of rated motor current.
4. Status inputs for belt drive electric motors: Current sensing transmitter with linear 4-20mA output

I. Electronic Valve/Damper Position indication: Visual scale indicating percent of travel

J. Air Differential Pressure sensors: application. Setra 264 or equal. These sensors shall be utilized for filter status, duct static pressure & other.

2.12 ELECTRO-MECHANICAL THERMOSTATS

A. Fire-Protection Thermostats: UL listed with fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature, with the following:
1. Reset: Automatic with control circuit arranged to require manual reset at central control panel, with pilot light and reset switch on panel labeled to indicate operation.

B. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point. Setpoint shall be adjustable.
1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

C. Electric space thermostats: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

D. Aquastat: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

2.13 ECM SPEED CONTROLLERS

A. PRICE DELUXE ECM Speed Controller
1. General: Speed controller for high efficiency ECM motor. Low voltage (24VAC) speed control to allow full manual (push button adjust) or BAS (2-10VDC signal) control of the ECM motor. And interface with the BMS
2. Features:
a. Dual outputs for controlling 2 ECM motors
b. Red four-digit digital display for reading out:
1) Speed 0 -100%
2) Motor RPM

3) BAS input voltage

c. Building Automation System input (2-10VDC) for remote

Specifications		
Display	**Mode**	**Range**
L.SEt	Local Setpoint - Manual Speed Adjust Mode (use UP/DOWN to adjust)	0-100%
rPn	RPM - Shows current RPM mode of ECM motor 1. If E001 is displayed – no RPM pulses are being read. Check 6 position cable. If E002 is displayed – RPM reading is over 3000 RPM. Check primary air.	0-2500 RPM
bAS.r	BAS remote - BAS Mode – Voltage Signal (Max display reading is 9.99 VDC)	0-9.99 VDC
bAS.S	BAS Setpoint - Current BAS setpoint	0-100%

Power:	24 VAC +-10% @ 50/60Hz (2VA)
Operating Conditions:	0°C to 50°C (32°F to 122°F) 0% – 95% R.H. non-condensing
Storage Conditions:	-30°C to 50°C (-22°F to 122°F) 0% – 95% R.H. non-condensing
Processor:	8-bit enhanced flash microcontroller
Inputs:	1 Analog (BAS) and 3 digital inputs (push buttons and RPM)
Outputs:	2 Digital (GO signal to ECM and Vspd PWM signal @ 80.0 Hz), Display, and aux analog output
Connections:	¼” Spade Terminals – Recommend 16 - 22AWG copper wire
Dimensions:	2.8" by 3.8" [71mm by 96mm] (includes mounting plate)
Shipping Weight:	0.220 lbs, 100 grams

2.14 CONTROL VALVES

A. Refer to 230923.11 CONTROL VALVES

B. Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

C. Terminal Unit Control Valves: Two ports as indicated, replaceable plugs and seats, and union and threaded ends.
1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

2.15 CONTROL EQUIPMENT

A. Refer to the following section for control device specifications
1. 230923.11 Control Valves
2. 230923.12 Control Dampers
3. 230923.23 Pressure Instruments
4. 230923.27 Temperature Instruments

PART 3 - EXECUTION

3.1 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others.

3.2 INSTALLATION

A. Verify mounting heights in first paragraph below with authorities having jurisdiction to comply with requirements of the Americans with Disabilities Act.

B. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 60 inches above the floor.
   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

C. Install guards on thermostats or flat plate stainless steel sensors in the following locations:
   1. Where indicated.

D. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

E. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

F. Wall mounted temperature sensors shall be flush mounted and shall be vandal resistant. The use of return air temperature sensors in high abuse areas shall be reviewed and approved by Owner. Space temperature sensors shall not be located on exterior walls, near lights or where sensing could be affected by heat producing devices. Sensors in non-client areas, such as administration areas, may be standard wall mounted sensors.
   1. Sensors shall be 1000omh thermistor type.
   2. Ducts or mixing boxes equal or greater than 16 square feet shall utilize averaging type sensors unless otherwise specified

G. Provide all relays, switches, and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified. All field wiring shall be by this contractor.

H. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by the control equipment manufacturer.

I. Mount surface-mounted control devices on brackets to clear the final finished surface on insulation.

J. Install equipment level and plumb.

K. Install control valves horizontally with the power unit up.

L. Unless otherwise noted, install wall mounted thermostats and humidistat 60” above the floor measured to the center line of the instrument, or as otherwise directed by the Architect.

M. Install averaging elements in ducts and plenums in horizontal crossing or zigzag pattern.

N. Install outdoor sensors in perforated tube and sunshield.

O. Install damper motors on outside of duct in protected areas, not in locations exposed to outdoor temperatures.

P. Install labels and nameplates on each control panel listing the name of the panel referenced in the graphics and a list of equipment numbers served by that panel.

Q. Furnish hydronic instrument wells, valves, and other accessories to the mechanical contractor for installation.

R. Furnish automatic dampers to mechanical contractor for installation.

3.3 GRAPHIC DISPLAY GENERATION

A. All software shall be capable of providing color graphics. All software shall include a graphical viewing and control environment and definition and construction of dynamic color graphic displays.

B. Provide a main default screen showing the basic layout of the building. Each color graphic screen shall have transfer links to allow the building operator to transfer between system associated screens (both forward and backward), as well as a transfer link back to the main default screen.

C. Basic CAD floor plans with layers for walls, windows, low pressure ductwork only, supply diffusers and room numbers shall be provided for all CV, VAV, and FPVAV terminal units. Floor plans shall show the location of each space temperature sensor with a dashed line to the associated terminal unit. Display in real time the difference between the space temperature and the current setpoint.
   1. Display the
      a. cooling %,
      b. heating % (if applicable)
      c. current CFM of each terminal unit.
   2. Provide a transfer link for each terminal unit to allow the operator to access the flow graphic for each individual terminal unit. Use a different color to shade the background area for each part of a floor plan graphic served by a different air handling unit.

D. Thermal floor plan graphics:

1. Show heating and cooling zones throughout the building in a range of colors (minimum 5) that provide a visual display of temperatures relative to their respective setpoints. The colors shall be updated dynamically as zones' comfort conditions change. Locations of space sensors shall also be shown for each zone. Floor plan humidity's shall be represented similarly to zone temperatures. Setpoint adjustment and color band displays shall be provided as a tool for user adjustment.
2. These full screen plans shall be accessible by rolling over the floor on the building elevation rendering. This will provide the viewer a quick and accurate overview of which zones are at setpoint, near setpoint, or need attention.
3. The viewer may then click on any zone to be brought to the terminal unit that is related to that zone. Rolling over any zone will bring up the zone description and temperature in a pop-up flag. Flags are used to keep the zone information legible regardless of how small the zone is depicted on the plan
4. All floor plans shall be vector based to allow for zooming in and out of floor plans without pixelization.
5. If zone lighting controls are tied into the BAS, then produce the same floor viewing and control for lights.
6. If a Web-based graphical interface is specified, then the floor plan graphics shall be accessible through the Web Browser Interfaces.

E. All control set points shall be easily adjustable from the system's color graphic screen by operators with the proper access level. Each controlled point on the BAS operator workstation color graphic screens shall have the set point indicated along with the actual controlled variable reading (preferred set point on top and actual reading on bottom). All points shall indicate the associated engineering unit. All analog outputs points shall indicate engineering units such as "%-open" or "%-closed" as required by the application. All normally closed or normally open points shall indicate the normal position (such as "N.C." or "N.O." next to the controlled device).

F. Provide system color graphics for each HVAC system and for each electrical, plumbing and/or piping system that is monitored and/or controlled by the BMS. Provide scaled floor plans indicating equipment location, service, and system data as required.

G. Provide color graphic floor plan displays and system schematics for each piece of mechanical equipment, including but not limited to air handling units, chilled water systems and hot water systems to optimize system performance analysis and speed alarm recognition.

H. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.

I. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.

J. The windowing environment of the operator interface shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
   1. Provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.

2. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points which aids the operator in the analysis of the facility.

K. Provide an automatically updated, dynamic display of the site-specific BMS architecture indicating the status of primary and secondary controllers.

L. Provide a separate dynamic display page of each HVAC (AHU, AC, chiller, cooling tower, fuel oil, etc.), electrical, and/or plumbing system connected to the BMS.

M. Provide a separate dynamic display page of each piece of terminal equipment (VAV box, fan coil unit, etc.) connected to the BMS.

N. Provide an additional dynamic, graphic display pages as required by the operating staff to further assist in daily system operations.

O. Graphics shall incorporate all system integration points communicated via hardware or software gateways and/or interfaces. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

P. Each graphic shall have a "BACK" button and a "HOME" or "MAIN" button located in the same location on all graphics.

Q. The operator shall be able to clearly distinguish the difference between the following types of points on a graphic either by color, shape, icon or text label:
1. Real-time sensor reading
2. Setpoint
3. Manually set vs. program set Setpoint
4. Real-time output reading
5. Manually Overridden or commanded output vs program set output
6. Status feedback from a piece of equipment vs the output command

R. Make appear links to additional information associated with the system on the graphic, such as:
1. Controls as-built schematics and wiring diagrams
2. As-built Sequence of Operation
3. Mechanical drawings
4. Electrical drawings

S. Integration graphics shall be representative of personnel standing in front of equipment. The graphics for equipment specified in the Building Systems Integration paragraph shall be representative of the manufacturers' local display panel and each shall be completely operable from the computer workstation.

3.4 ELECTRICAL WIRING SCOPE

A. This contractor shall be responsible for power that is not shown on the electrical drawings, to controls furnished by this contractor. If power circuits are shown on the electrical drawings, this contractor shall continue the power run to the control device. If power circuits are not shown, this contractor shall coordinate with the electrical contractor to provide breakers at distribution panels for power to controls. This contractor is then responsible for power from the distribution panel.

1. Coordinate panel locations. If enclosures for panels are shown on the electrical drawings, furnish the enclosures according to the electrician's installation schedule.

B. This contractor shall not be responsible for power to control panels and control devices that are furnished by others, unless it is part of the control interlock wiring.

C. Refer to Coordination section for what devices this contractor is responsible to mount, and which are turned over to others to mount.

D. This contractor shall be responsible for wiring of any control device that is furnished as part of this section of specification.

E. Interlock wiring shall be run in separate conduits from BAS associated wiring.

F. Provide network wiring for equipment that is called to be integrated to the BAS.

3.5 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Install hard-wired signal and communication cable/wire according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables & Division 27 Section "Communications Horizontal Cabling."
1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Provide electrical box fastened to wall framing with raceway to accessible area with plastic bushings for all wall sensor locations.
3. Install exposed cable in enclosed raceway or above ceilings.
4. Concealed cable installed in accessible locations shall be plenum rated and installed without conduit or raceways. All wiring shall be run parallel to building lines and be supported every 5 feet with bridle rings or similar hangers. Cable shall not be attached to threaded rod or hot and chilled water piping.
5. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
6. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
7. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
8. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Connect manual-reset limit controls independent of manual-control switch positions.

D. All low voltage control wiring shall be class 2. Control wiring that is not class 2 shall be run in separate conduits from class 2 wiring.

E. Floor level network wiring between terminal units can be combined with thermostat and other low voltage wiring in the same conduit. All other network wiring shall be in dedicated conduits.

F. Install raceways, boxes, and cabinets according to Division 26 Section "Raceways and Boxes."

G. Install building wire and cable according to Division 26 Section "Conductors and Cables."

H. Installation shall meet the following requirements:
1. Conceal cable and conduit, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway or conduit.
3. Install concealed cable using plenum rated cable.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. Supported risers shall be EMT.

I. Rigid conduit shall be steel, hot dip galvanized, threaded with couplings, ¾ inch minimum size, manufactured in accordance with ANSI C-80-1. Electrical metallic tubing (EMT) with compression fittings or intermediate metallic conduit (IMC) may be used as conduit or raceway where permitted by the NEC.

J. Concealed control conduit and wiring shall be provided in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

K. Install conduit adjacent to machine to allow service and maintenance.

L. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

M. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

N. Ground equipment.

3.6 COMMUNICATION WIRING

A. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer’s installation recommendations for all communication cabling.

B. Do not install communication wiring in raceway and enclosures containing Class 1 wiring.

C. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

D. Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

E. Cable bundling:

1. RS485 cabling run open air in accessible areas can be bundled with other class 2 low voltage cabling.
2. RS485 cabling run between terminal units in conduits above ceilings or under floors or in inaccessible areas can be bundled with other class 2 low voltage cabling.
3. RS485 cabling run between floors shall be in a communication only conduit.
4. RS485 conduit run long distances between utility rooms or between buildings shall be in a communication only conduit.
5. Ethernet cabling shall be in a communication only conduit.
6. Ethernet and RS485 can be run together.
7. Fiber optics can be run with Ethernet and RS485 cabling as long as the conduit is bent to fiber optic standards and junction boxes are sized for fiber optic use.

F. RS485 Cabling
1. RS485 cabling shall be used for BACnet MS/TP networks.
2. RS485 shall use low capacitance, 20-24 gauge, twisted shielded pair.
3. The shields shall be tied together at each device.
4. The shield shall be grounded at one end only and capped at the other end.
5. Provide end of line (EOL) termination devices at each end of the RS485 network or subnetwork run, to match the impedance of the cable, 100 to 120ohm.

G. Ethernet Cabling
1. Ethernet shall not be run with any Class 1 or low voltage Class 2 wiring.
2. CAT6, unshielded twisted pair (UTP) cable shall be used for BAS Ethernet.
3. Solid wire shall be used for long runs, between mechanical rooms and between floors. Stranded cable can be used for patch cables and between panels in the same mechanical room up to 50 feet away.
4. When the BAS Ethernet connects to an Owner's network switch, document the port number on the BAS As-builts.

H. Fiber-Optic Cabling
1. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.
2. All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.
3. All terminations shall be made into a patch panel, designed for such use. Free air terminations with patch panels are prohibited.

I. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to the manufacturer's instructions.

J. All runs of communication wiring shall be unspliced length when that length is commercially available.

K. All communication wiring shall be labeled to indicate origination and destination data.

L. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.7 IDENTIFICATION

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.
   1. Labels shall use white lettering (12-point type or larger) on a red background.
   2. Warning labels shall read as follows: C A U T I O N This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to “Off” position before servicing.

B. Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
   1. Labels shall use white lettering (12-point type or larger) on a red background.
   2. Warning labels shall read as follows: C A U T I O N This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

C. Control Equipment and Device labeling:
   1. Labels and tags shall match the unique identifiers shown on the as-built drawings.
   2. All Enclosures shall be labeled to match the as-built drawing by either control panel name or the names of the DDC controllers inside.
   3. All sensors and actuators not in occupied areas shall be tagged.
   4. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMS flow coefficient.
   5. Duct static pressure taps shall be tagged at the location of the pressure tap.
   6. Each device inside enclosures shall be tagged.
   7. Terminal equipment need only have a tag for the unique terminal number, not for each device. Match the unique number on:
      a. First, the design drawings, or
      b. Second, the control as-builts, or
      c. Third, the DDC addressing scheme
   8. Tags on the terminal units shall be displayed on the Operator Workstation Graphics.
   9. Tags shall be mechanically printed on permanent adhesive backed labeling strips, 12 point height minimum.

D. Manufacturers’ nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

E. Identification of Wires
   1. Tag each wire with a common identifier on each end of the wire, such as in the control panel and at the device termination.
   2. Tag each network wire with a common identifier on each end.
   3. Tag each 120V power source with the panel and breaker number it is fed by.

F. Identification of Conduits:
   1. Identify the low voltage conduit runs as BAS conduit, power feeds not included.
   2. Identify each electric box, junction box, utility box and wiring tray with a blue paint mark or blue permanent adhesive sticker.
   3. For conduit runs that run more than 8 ft between junction boxes in 1 room, place a blue identifier at least every 8 feet.
   4. Place a blue identifier on each side of where a conduit passed through a wall or other inaccessible path.

5. Identify all BAS communication conduits the same as above.

3.8 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 unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

C. DDC Verification:
1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.
8. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
9. Check DDC system as follows:
    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

D. Engage a factory-authorized service representative to perform startup service.

E. Replace damaged or malfunctioning controls and equipment.
1. Start, test, and adjust control systems.
2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

3.9 SYSTEM CHECKOUT AND STARTUP

A. Inspect each termination in the MER control panels and devices to make sure all wires are connected according to the wiring diagrams and all termination are tight.

B. After the controls devices and panels are installed and power is available to the controls, perform a static checkout of all the points, including the following:
   1. Inspect the setup and reading on each temperature sensor against a thermometer to verify its accuracy.
   2. Inspect the setup and reading on each humidity sensor against a hygrometer to verify its accuracy.
   3. Inspect the reading on each CO2 sensor using a calibration kit to verify the sensor range accuracy matches the DDC setup.
   4. Inspect the reading of each status switch to verify the DDC reads the open and close correctly.
   5. Command each relay to open and close to verify its operation.
   6. Command each 2-position damper actuator to open and close to verify operation.
   7. Command each 2-position valve to open and close to verify operation.
   8. Ramp each modulating actuator to 0%, 25%, 50%, 75% and 100% to verify its operation.
   9. Ramp each modulating output signal, such as a VFD speed, to verify its operation.
   10. Test each safety device with a real life simulation, for instance check low temperature detectors with ice water, water detectors with water, etc.

C. Document that each point was verified and operating correctly. Correct each failed point before proceeding to the dynamic startup.

D. Verify that each DDC controller communicates on its respective network correctly.

E. After all of the points are verified, and power is available to the mechanical system, coordinate a startup of each system with the mechanical contractor. Include the following tests:
   1. Start systems from DDC.
   2. Verify that each setpoint can be met by the system.
   3. Change setpoints and verify system response.
   4. Change sensor readings to verify system response.
   5. Test safety shutdowns.
   6. Verify time delays.
   7. Verify mode changes.
   8. Adjust filter switches and current switches for proper reactions.
   9. Adjust proportional bands and integration times to stabilize control loops.

F. Perform all program changes and debugging of the system for a fully operational system.

G. Verify that all graphics at the operator workstations correspond to the systems as installed. Verify that the points on the screens appear and react properly. Verify that all adjustable setpoints and manual commands operate from the operator workstations.

H. After the sequence of operation is verified, setup the trends that are listed in the sequence of operations for logging and archiving for the commissioning procedure.

3.10 COMMISSIONING:

A. The BAS Contractor shall prepare and submit for approval a complete acceptance test procedure including submittal data relevant to point index, functions, sequence, inter-locks, and associated parameters, and other pertinent information for the operating system. Prior to acceptance of the BAS by the Owner and Engineer, the BAS contractor shall completely test the BAS using the approved test procedure.

B. After the BAS contractor has completed the tests and certified the BAS is 100% complete, the Engineer shall be requested, in writing, to approve the satisfactory operation of the system, sub-systems and accessories. The BAS contractor shall submit Maintenance and Operating manuals at this time for approval. An acceptance test in the presence of the Engineer and Owner's representative shall be performed. The Owner will then shake down the system for a fixed period of time (30 days).

C. The BAS contractor shall fix punch list items within 30 days of acceptance.

D. When the system performance is deemed satisfactory in whole or in part by these observers, the system parts will be accepted for beneficial use and placed under warranty.

3.11 PROJECT CLOSEOUT

A. Acceptance testing before commissioning.
   1. Upon completion of the installation, the Control System Contractor shall load all system software and start-up the system. The Control System Contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to ensure that the system is functioning in full accordance with these specifications.
   2. The Control System Contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.
   3. System Acceptance: Satisfactory completion is when the Control System Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner’s Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

B. Operation & maintenance manuals
   1. O&M manuals shall include the following elements, as a minimum:
      a. As-built control drawings for all equipment.
      b. As-built Network Communications Diagram. The Diagram shall be complete with all field locations and network identifiers and associated controller part number.
      c. Completed Valve and damper schedules.
      d. Manufacturer equipment data sheets and specifications for all components.
      e. Completed Performance Verification sheets.
      f. Completed Controller Checkout/Calibration sheets.
      g. Completed pressure and temperature default setpoints sheets.
      h. Service and installation manuals.
      i. Itemized list and periodical rate requirements for maintenance.
      j. Maintenance Item work plan.

C. Maintenance contract
   1. The contractor shall provide OMH and its representatives with a maintenance contract proposal upon final acceptance. The contractor shall provide a maintenance proposal as per OMH requirements. This section shall complement but shall not supersede OMH specifications and requirements. The Contractor shall provide a complete itemized list and periodical rates of maintenance as prescribed herein.
      a. The contractor shall provide cost options in their proposed submissions.
      b. Cost options shall be presented as individual proposals. Each proposal shall be unique. Multiple services/costs in one proposal shall not be acceptable.
      c. The proposals shall be clear and detailed for all specific services included and services that are not included.
      d. The contractor shall include a complete list of components, including but not limited to:
         1) Server Hardware and software maintenance.
         2) DDC controller Hardware and software maintenance.
         3) Temperature sensors and meters.
         4) Valve and dampers maintenance.
      e. The proposal shall state specific dates and timelines of said services.
      f. The proposal shall provide a complete bill of materials list that shall be provided and stocked at client's site.
      g. The Contractor shall include labor time in their contract to provide 16 hours of training.
      h. Time and material rates.
      i. The Contractor shall budget a minimum of 4 days per year for contractor's stake holders and technical representatives to meet with the client and their representatives to discuss performance of system and services.

3.12 WARRANTY

A. Controls contractor shall warranty all control system components, programming, and operation for a period of one (1) year from system acceptance Per Phase.

B. The warrantee period starts after each phase when the owner has beneficial occupancy of the completed phase.

C. Warranty period services
   1. Equipment, materials, and workmanship incorporated into the work shall be warranted for a period of one year from the time of system acceptance.
   2. Within this period, upon notice by the Owner, any defects in the BMS due to faulty materials, methods of installation or workmanship shall be promptly repaired or replaced by the Control System Contractor at no expense to the Owner.
   3. Maintenance of Computer Software Programs: The Control System Contractor shall maintain all software during the warranty period. In addition, all factory or sub-vendor upgrades to software shall be added to the systems, when they become available, at no additional cost. New products are not considered upgrades in this context.
   4. Maintenance of Control Hardware: The Control System Contractor shall inspect, repair, replace, adjust, and calibrate, as required, the controllers, control devices and associated peripheral units during the warranty period. The Control System Contractor shall then furnish a report describing the status of the equipment, problem areas (if any) noticed

during service work, and description of the corrective actions taken. The report shall clearly certify that all software is functioning correctly.

5. Service Period: Calls for service by the Owner shall be honored within 24 hours and are not to be considered as part of routine maintenance.
6. Service Documentation: A copy of the service report associated with each owner-initiated service call shall be provided to the owner.

D. Warranty access

1. The Owner shall grant to the Control System Contractor reasonable access to the BMS during the warranty period. Remote access to the BMS (for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period) will be allowed.

3.13 SYSTEM ADJUSTMENT AND CALIBRATION

A. Completely adjust and calibrate the control system. Review the operation of each system input and output, control loops and/or software routings, timing functions, operator entered constants and facilities management functions and observe that they perform their intended functions. When above procedure has been completed and the control system is operating satisfactorily, submit a letter with one (1) copy of completed values and points log to the Owner's Representative advising them that the control system is 100% complete and operates in accordance with the Contract Documents.

3.14 INSTRUCTIONS TO THE OWNER'S REPRESENTATIVE

A. Controls training shall be completed after each phase.

B. The following training shall be accomplished after the completion of each phase

1. Provide competent control technicians to instruct the Owner's operating personnel and turn over three (3) copies of Controls As-Builts.
2. Provide a total of sixteen (16) hours of instruction at the site, during start-up.
3. Provide twenty-four (24) hours of instruction at the site after start-up
   a. Provide one (1) day at three (3) months after start-up training
   b. Provide one (1) day at six (6) months after start-up training.
   c. Provide one (1) day at nine (9) months after start-up training.

C. Operator training

1. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer’s standard pricing such as transportation, meals, etc.
2. The Contractor shall provide training in the operation, adjustment and maintenance of the HVAC and control system as outlined below and as required by other sections in specifications.
3. Training shall be provided by knowledgeable instructors thoroughly familiar with all aspects of installed system.
4. The training shall be specific to the installed system and not generic in nature.
5. All equipment and material required for classroom training, including printed materials, shall be provided by the Control System Contractor.

6. Upon acceptable commissioning review from the commissioning agent and at such time acceptable to the client and performance of the Control System hardware and software has been established, the Control System Contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction shall be done during normal working hours and shall be performed by a competent factory certified and provided representative familiar with the system hardware, software, and accessories.
7. **The Control System Contractor shall provide 40 hours of comprehensive training in two separate sessions (80 hours total) for system orientation, product maintenance and troubleshooting, programming, and engineering.**
8. The Control System Contractor shall provide 16 hours (total) of instruction to the owner's designated personnel on the operation of the BMS and describe its intended use with respect to the programmed functions specified. Operator orientation of the BMS shall include, but not be limited to; the overall operation program, equipment functions (both individually and as part of the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the System's operation.
9. Training shall include but not be limited to: changes to set-points, scheduling, reset schedules, enable/disable commands, and trending.
10. The Control system contractor shall provide course outline as itemized below at a minimum.
    a. Scheduling functionality and configuration
    b. Alarming points, configuration, and acknowledgement
    c. Trending points and configuration and exporting to excel
    d. Backing up field controllers
    e. Backing up the server
    f. Graphical functionality and configuration
    g. Programming controller’s introduction only, demonstration of software tools provided by contractor.
    h. Sequences of operation for each asset
    i. Changing modifying setpoints.
    j. Controller hardware technical identification and maintenance.
    k. Network layout and field point identification and maintenance
    l. Demonstration and training of all software tools shall be provided before closeout

D. Remote Owner Training can be provided at Owner’s request. Training Class would be provided by Trane. Owner to cover travel expenses.

3.15 SYSTEM MAINTENANCE

A. Perform Building Automation System preventative maintenance and support for a period of 1 year. Quarterly (Four (4) visit) 1 Day each, beginning the date of substantial completion.
1. Complete Building Automation System inspections, in addition to normal warranty requirements. Inspections to include:
2. System Review – Review the BAS to correct programming errors, failed points, points in alarm, and points that have been overridden manually.
3. Seasonal Control Loop Tuning – Control loops are reviewed to reflect changing seasonal conditions and / or facility heating and cooling loads
4. Sequence of operation verification – Systems all verified to be operating as designed and in automatic operation. Scheduling and setpoints are reviewed and modified.
5. Database back-up

6. Operator coaching
7. Technician shall review critical alarm log and advise owner of additional services that may be required.
8. Technician shall provide a written report to owner after each inspection.

END OF SECTION 230900

SECTION 230923.11 - 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 230900 – INSTRUMENTATION AND CONTROL FOR HVAC
      a. Control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

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.
   5. Schedule and manufacturers 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.
   6. 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:
   7. Control valve installation location shown in relationship to room, duct, pipe, and equipment.
   8. Size and location of wall access panels for control valves installed behind walls.
   9. Size and location of ceiling access panels for control valves installed above inaccessible ceilings.

1.5 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. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Backup Power Source: Systems and equipment served by a backup power source shall have associated control valve actuators served from a backup power source.

E. Environmental Conditions:

1. Provide electric control valve actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control valve 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.

F. Determine control valve sizes and flow coefficients by ISA 75.01.01.

G. Control valve characteristics and rangeability shall comply with ISA 75.11.01.

H. Selection Criteria:
1. Control valves shall be suitable for operation at system pressures and temperatures
2. Control valve shutoff classifications shall be FCI 70-2, Class IV or better unless otherwise indicated.
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 linear or equal percentage flow-throttling characteristics.
7. Fail positions unless otherwise indicated:
   a. Cooling Water: Close.
   b. Heating Water: Open.
   c. Reheat Water: Open
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 fully 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 5 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 valve inlet pressure.
    b. 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 water systems, use ball- or globe-style control valves for two-position control for valves NPS 2 and smaller and butterfly style for valves larger than NPS 2.
17. 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. 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. Belimo Aircontrols (USA), Inc.
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 (Stainless Steel).
   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. Ball Valves with Full Ball and Characterized V-Notch:
   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. Flow-Tek, Inc.
   2. Performance:
      a. Process Temperature Rating: Minus 20 to plus 500 deg F.
      b. ASME B16.34, Class 600 for NPS 2 and smaller; Class for larger than NPS 2.
      c. Leakage: FCI 70-2, Class VI, bi-directional.
      d. Rangeability: Varies from 200 to 1 up to 800 to 1 based on notch pattern of ball.
      e. Rotation: Zero to 90 degrees.
      f. Equal percentage flow characteristic.
      g. Full port.
   3. Face-to-Face Dimension: ASME B16.10 long pattern.
   4. Valves NPS 2 and Smaller: ASME B1.20.1 threaded (NPT) ends and three-piece body.
   5. Valves NPS 2-1/2 through NPS 12: Flanged ends suitable for mating to ASME B16.5 flanges and two-piece body.
   6. Hole in the stem slot of each ball equalizes pressure between the body cavity and the line media flow.
   7. Replaceable seat, ball, and shaft packing.
   8. Body: stainless steel.
   9. Ball and Shaft: Stainless steel.
   10. Ball Seat: RPTFE.
   11. Stem Seals for Valves NPS 2 and Smaller: Live-loaded, self-adjusting, primary, and secondary sealing using belleville washers.
      a. Primary Seal: Combination of thrust washer and thrust washer protector.

b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.

12. Stem Seals for Valves Larger than NPS 2: Independent packing gland, adjusted without removing mounting hardware or operator, and contoured to uniformly distribute load across packing.
    a. Primary Seal: Combination of thrust washer and thrust washer protector.
    b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.
13. Label each valve with following:
    a. Manufacturer's name, model number, and serial number.
    b. Body size.
    c. Flow directional arrow.

C. Pressure-Independent Ball Valves NPS 2 and Smaller:
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. Belimo Aircontrols (USA), Inc.
    b. Griswold Controls.
    c. HCI; Hydronics Components Inc.
2. Performance:
    a. Pressure Rating: 600 psig for NPS 1 and 400 psig for NPS 1-1/2 and NPS 2.
    b. Close-off pressure of 200 psig.
    c. Process Temperature Range: Between zero to 212 deg F.
    d. Rangeability: 100 to 1.
3. Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.
4. Body: Forged brass, nickel plated, and with threaded ends.
5. Ball: Chrome-plated brass.
6. Stem and Stem Extension: Chrome-plated brass, blowout-proof design.
7. Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
8. Ball Seats: Reinforced PTFE.
9. Stem Seal: Reinforced PTFE packing ring stem seal with 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 equivalent cycle endurance can be achieved.
10. Flow Characteristic: Equal percentage.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. Commercial-Grade, Two-Way Butterfly Valves:
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. Keystone; Emerson Electric Co.
    b. Siemens Industry, Inc. (Building Technologies Division).
2. Performance:
    a. Bi-directional bubble tight shutoff at 250 psig.
    b. Comply with MSS SP-67 or MSS SP-68.
    c. Rotation: Zero to 90 degrees.

d. Linear or modified equal percentage flow characteristic.

3. Body: Cast iron ASTM A126, Class B, ductile iron ASTM A536 or cast steel ASTM A216/A216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
4. Disc: 316 stainless steel.
5. Shaft: 316 or 17-4 PH stainless steel.
6. Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
7. Shaft Bushings: Reinforced PTFE or stainless steel.
8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:
   a. Manufacturer's name, model number, and serial number.
   b. Body size.
   c. Body and trim materials.
   d. Flow arrow.

2.4 SOLENOID VALVES

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. ASCO Valve, Inc.

B. Description:
   1. Action: Either normally open or normally closed in the event of electrical power failure as required by the application.
   2. Size to close against the system pressure.
   3. Manual override capable.
   4. Heavy-duty assembly.
   5. Body: stainless steel.
   6. Seats and Discs: NBR or PTFE.
   7. Solenoid Enclosure: NEMA 250, Type 4.

2.5 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

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. Belimo Aircontrols (USA), Inc.
   2. Honeywell.
   3. Johnson Controls, Inc.
   4. Siemens Industry, Inc. (Building Technologies Division).

B. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

C. Actuators for Steam Control Valves: Shutoff against 1.5 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: 24-V ac.

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 counterclockwise 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- 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. Position Feedback:
   1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
   2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
   3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

N. 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.

O. 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.

P. 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.

Q. 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.

R. 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.

S. Stroke Time:
1. Operate valve from fully closed to fully open within 60 seconds.
2. Operate valve from fully open to fully closed within 60 seconds.
3. Move valve to failed position within 5 seconds.
4. Select operating speed to be compatible with equipment and system operation.

T. Sound:
1. Spring Return: 62dBA.
2. Non-Spring Return: 45dBA.

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 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 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.

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 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. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve larger than NPS 2.

D. Install pressure temperature taps in piping upstream and downstream of each control valve larger than NPS 1.

E. 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.

F. 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.

G. 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.

H. 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.

3.5 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 valve identification on valve and on face of ceiling directly below valves concealed above ceilings.

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 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. Verify that control valves are installed correctly for flow direction.
5. Verify that valve body attachment is properly secured and sealed.
6. Verify that valve actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that valve ball, disc, and plug travel are unobstructed.
9. 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.

3.9 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.

3.10 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

B. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of four (4) hours of instruction at the site, during start-up.
   3. Provide four (4) hours of instruction at the site after start-up
      a. Provide two (2) hours at three (3) months after start-up training
      b. Provide one (1) hour at six (6) months after start-up training.
      c. Provide one (1) hour at nine (9) months after start-up training

END OF SECTION 230923.11

SECTION 230923.12 - CONTROL DAMPERS

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 REFERENCES

A. AMCA 500-D – Laboratory Methods for Testing Dampers for Ratings

B. AMCA 511 - Certified Ratings Program for Air Control Devices.

C. ASHRAE RP1157 – Research project for determining damper placement and programming.

1.3 DEFINITIONS

A. Damper Terminology: Definitions of terms for metal louvers contained in AMCA 500 apply to this Section unless otherwise defined in this Section or in referenced standards

B. Horizontal Damper: Damper with horizontal blades; i.e., the axes of the blades are horizontal.

C. Vertical Damper: Damper with vertical blades; i.e., the axes of the blades are vertical.

1.4 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. Electric and electronic actuators.

B. Related Requirements:
   1. SECTION 230900 – INSTRUMENTATION AND CONTROL FOR HVAC
      a. Control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.5 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.

1.6 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.
5. Include leakage, pressure drop, maximum pressure data, and damper authority.
6. Indicate materials, construction, dimensions, and installation details.
7. Include damper pressure drop data for all damper sizes in accordance with AMCA 500-D test figure 5.3 (Duct Inlet, Duct Outlet).
8. Indicate damper leakage meets AMCA Class 1A in accordance with AMCA 500-D.
9. Indicate damper is licensed to bear the AMCA Certified Ratings Seal for Air Performance and Air Leakage.
10. Damper to be tested specifically to project specifications in an AMCA approved laboratory when applicable.
11. Include a copy of the installation instructions.
12. Certifications: Manufacturer shall certify in writing that the damper capacity will withstand HVAC system operating conditions.
13. Closed position: Maximum pressure of 13 inches w.g. (3.2 kPa) @ a 12 inch (305 mm) blade length.
14. Open Position: Maximum air velocity of 6000 feet per minute (1829m/min).
15. Product Schedule: For dampers. Use same designations indicated on drawings.
16. Shop Drawings:
17. Include plans, elevations, sections, and mounting details.
18. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
19. Include diagrams for power, signal, and control wiring.
20. Include diagrams for pneumatic signal and main air tubing.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications
1. The manufacturer shall have implemented the management of quality objectives, continual improvement, and monitoring of customer satisfaction to assure that customer needs and expectations are met.
2. Manufacturer shall be International Organization for Standardization (ISO) 9001 accredited.

B. Product Qualifications
1. Dampers to be tested in accordance to project specification or published data sheets. Test set up orientation to be per AMCA 500 D. Leakage and pressure drop will be recorded and submitted for review and acceptance.

2. Dampers shall be licensed to bear the AMCA Certified Ratings Seal. Ratings based on tests and procedures performed in accordance with AMCA 511 and comply with AMCA Certified Ratings Program. AMCA Certified Ratings Seal applies to Air leakage and AIR Performance.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.

B. Storage: Store materials in a dry area indoors, protected from damage and in accordance with manufacturer's instructions.

C. Handling: Handle and lift dampers in accordance with manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage.

1.9 WARRANTY

A. Manufacturer shall provide standard limited warranty that product will be free from defects in material and workmanship for a period of 5 years (60 months) from date of delivery to the delivery location. When notified in writing from the Owner of a manufacturing defect, manufacturer shall promptly correct deficiencies without direct financial cost to the Owner.

1.10 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. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.

E. 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.
2. Fail positions unless otherwise indicated:
   a. Supply Air: Close.
   b. Return Air: Close.
   c. Outdoor Air: Close.
   d. Mixed Air: Open.
   e. Exhaust Air: Close.
3. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
4. Select modulating dampers for a pressure drop of 2 percent of fan total static pressure unless otherwise indicated.
5. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.

F. 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. Damper actuator shall be factory installed by damper manufacturer as integral part of damper assembly. Coordinate actuator location and mounting requirements with damper manufacturer.

G. Rectangular Dampers with Aluminum Airfoil Blades:
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. Arrow United Industries.
   b. Ruskin Company.
2. 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.
3. Construction:
   a. Frame:
      1) Material: ASTM B211, 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 B211, 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 stainless 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 stainless 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.

4. Airflow Control:
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) Ebtron, Inc.
2) Ruskin Company.

b. Where indicated, provide damper assembly with integral airflow measurement and control.

c. A factory-furnished and -calibrated controller shall be programmed, in nonvolatile EPROM, with application-specific airflow set point and range.

d. The controller and actuator shall communicate to control the desired airflow.

e. The controller shall receive a zero- to 10-V dc input signal and report a zero- to 20-mA output signal that is proportional to the airflow.

f. Airflow measurement and control range shall be suitable for operation between 150 to 2000 fpm.

g. Ambient Operating Temperature Range: Minus 40 to plus 140 deg F.

h. Ambient Operating Humidity Range: 5 to 95 percent relative humidity, non-condensing.

i. Provide unit with control transformer rated for not less than 85 VA. Provide transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.

j. Provide screw terminals for interface to field wiring.

k. Factory mount electronics within a NEMA 250, Type 1 painted steel enclosure.

H. Rectangular Dampers with Aluminum Flat Blades:

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. Arrow United Industries.
   b. Ruskin Company.
2. Performance:
   a. Leakage: Leakage shall not exceed 3.2 cfm/sq. ft. against 1-in. wg differential static pressure.
   b. Pressure Drop: 0.07-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 2000 fpm.
   d. Temperature: Minus 50 to plus 250 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, not to exceed 3-in. wg.
   f. Damper shall have AMCA seal for both air leakage and air performance.
3. Construction:
   a. Frame:
      1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.12 inch thick.
      2) Hat-shaped channel with integral flanges.
      3) Width not less than 5 inches.
   b. Blades:
      1) Flat blades of extruded aluminum.
      2) Parallel or opposed blade configuration as required by application.
      3) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.12 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 stainless steel, mechanically attached to blades.
   e. Bearings:
      1) Molded-synthetic 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 stainless 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.

2.2 ROUND CONTROL DAMPERS

A. Round Dampers, Sleeve Type:
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. Ruskin Company.
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: stainless 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 stainless steel.
   c. Blade Seal: Polyethylene foam seal sandwiched between two sides of blades and fully encompassing blade edge.
   d. Axle: 0.5-inch-diameter stainless steel, mechanically attached to blade.
   e. Bearings: Stainless-steel sleeve pressed into frame.

B. Round Dampers, Flanged Type:
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. Arrow United Industries.
   b. Ruskin Company.
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: 0.03-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.

3. Construction:
   a. Frame:
      1) Size Range: 4 to 60 inches.
      2) Material: stainless 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 stainless 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 stainless- steel bar.
   d. Blade Seal: Neoprene, mechanically attached to blade and fully encompassing blade edge.
   e. Axle: stainless 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.

2.3 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. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its fully 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.

I. Actuator Fail Positions: As indicated below:
   1. Exhaust Air: Close.
   2. Outdoor Air: Close.
   3. Supply Air: Close.
   4. Return Air: Open.

2.4 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:
   1. 24 V.
   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.

C. 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.

D. 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.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. 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 counterclockwise 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 a 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 shall be factory or field programmable.
    2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
    3) Service data, including at a minimum, number of hours powered and number of hours in motion.

G. Position Feedback:
1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

H. 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.

I. 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.

J. 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.

K. 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.

L. 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.

M. Stroke Time:
1. Operate damper from fully closed to fully open within 15 seconds.
2. Operate damper from fully open to fully closed within 15 seconds.
3. Move damper to failed position within 5 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.

N. 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 CONTROL-DAMPER APPLICATIONS

A. Control Dampers:

B. Select from damper types indicated in "Control Dampers" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

3.3 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 when subjected to a force.

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.

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 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.
   1. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

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 damper identification on damper and on face of ceiling where damper is concealed above ceiling.

3.8 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 airline 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.

3.9 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.

3.10 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

B. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of four (4) hours of instruction at the site, during start-up.
   3. Provide four (4) hours of instruction at the site after start-up
      a. Provide two (2) hours at three (3) months after start-up training
      b. Provide one (1) hour at six (6) months after start-up training.
      c. Provide one (1) hour at nine (9) months after start-up training

END OF SECTION 230923.12

SECTION 230923.23 - 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 230900 – INSTRUMENTATION AND CONTROL FOR HVAC
      a. Control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

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.
   4. 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:
      a. Product installation location shown in relationship to room, duct, pipe, and equipment.
      b. Wall-mounted instruments located in finished space, showing relationship to light switches, fire alarm devices, and other installed devices.
      c. Size and location of wall access panels for instruments installed behind walls.
      d. Size and location of ceiling access panels for instruments installed in accessible ceilings.

1.5 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 and cooled, 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 4 or 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 4.
         2) Air-Moving Equipment Rooms: Type 1.

g. Localized Areas Exposed to Washdown: Type 4.
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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. Dwyer Instruments, Inc.
2. Insertion length shall be at 12 inches.
3. Sensor with four radial holes of 0.04-inch diameter.
4. 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 Insertion Static Pressure Sensor:
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. MAMAC Systems, Inc.
2. Sensor probe with two opposing orifices designed to reduce error-associated air velocity.
3. Sensor insertion length shall be 8 inches.
4. Construct sensor of Type 304 stainless steel.
5. Connection: Threaded, NPS 1/8 swivel fitting for connection to copper tubing or NPS 1/4 barbed fitting for connection to polyethylene tubing.
6. Sensor probe attached to a mounting flange with neoprene gasket and two holes for fasteners.
7. Mounting flange shall be suitable for flat oval, rectangular, and round duct configurations.
8. Pressure Rating: 10 psig.

C. Duct Traverse Static Pressure Sensor:
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. Air Monitor Corporation.
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.

D. Outdoor Static Pressure Sensor:
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. Dwyer Instruments, Inc.
2. Provides average outdoor pressure signal.
3. Sensor with no moving parts.
4. NEMA 250, Type 4X enclosure.
5. Pressure Connection: Brass barbed fitting for NPS 1/4tubing.
6. Conduit fitting around pressure fitting for sensor support and protection to pressure connection.

E. Space Static Pressure Sensor for Wall Mounting:
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. Dwyer Instruments, Inc.
2. 100-micron filter mounted in stainless-steel wall plate senses static pressure.
3. Wall plate provided with gasket and screws, and sized to fit standard single-gang electrical box.
4. Back of sensor plate fitted with brass barbed fitting for tubing connection.

F. Space Static Pressure Sensor for Recessed Ceiling Mounting:
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. Air Monitor Corporation.
2. Stainless-steel 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.

G. Space Static Pressure Sensor for Exposed or Suspended Mounting:
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. Air Monitor Corporation.
2. 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.

3. Stainless steel with perforations arranged to sense space static pressure. Exposed surfaces provided with brush finish.
4. Sensor fitted with multiple sensing ports, pressure impulse suppression chamber, and airflow shielding.
5. Surface-mounted sensor provided with solid mounting plate intended for mount to ceiling with pressure chamber exposed to view.
6. Surface-mounted sensor with 0.125-inch fitting for exposed tubing connection.
7. Suspended sensor intended for pendent mount with pressure chamber exposed to view.
8. Suspended sensor with NPS 1/2 fitting for exposed pipe or tubing connection.

2.3 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:
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. Dwyer Instruments, Inc.
2. Diaphragm operated to actuate an SPDT snap switch.
   a. Fan safety shutdown applications: Switch with manual reset.
3. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
4. Enclosure Conduit Connection: Knock out or threaded connection.
5. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
6. High and Low Process Connections: Threaded, NPS 1/8.
7. Enclosure:
   a. Dry Indoor Installations: NEMA 250, Type 1.
   b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
   c. Hazardous Environments: Explosion proof.
8. Operating Data:
   a. Electrical Rating: 15 A at 120- to 480-V ac.
   b. Pressure Limits:
      1) Continuous: 45 inches wg.
      2) Surge: 10 psig.
   c. Temperature Limits: Minus 30 to 180 deg F.
   d. Operating Range: Approximately 2 times set point.
   e. Repeatability: Within 3 percent.
   f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Air-Pressure Differential Switch with Set-Point Indicator:
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. Dwyer Instruments, Inc.
2. Diaphragm operated to actuate an SPDT snap switch.
3. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
4. Enclosure Conduit Connection: Knock out or threaded connection.

5. User Interface: Screw-type set-point adjustment with enclosed set-point indicator and scale.
6. High and Low Process Connections: Threaded, NPS 1/8.
7. Enclosure:
   a. Dry Indoor Installations: NEMA 250, Type 1.
   b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
   c. Hazardous Environments: Explosion proof.
8. Operating Data:
   a. Electrical Rating: 15 A at 120- to 480-V ac.
   b. Pressure Limits:
      1) Continuous: 10 psig.
      2) Surge: 25 psig.
   c. Temperature Limits: Minus 30 to 110 deg F.
   d. Operating Range: Approximately 2 times set point.
   e. Repeatability: Within 1 percent.
   f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Air-Pressure Differential Switch with Dual Scale Adjustable Set Point:
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. Dwyer Instruments, Inc.
2. Diaphragm operated to actuate an SPDT 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. High and Low Process Connections: Slip-on tubing connections.
7. Enclosure:
   a. Dry Indoor Installations: NEMA 250, Type 13.
8. 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.

D. Air-Pressure Differential Indicating Switch:
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. Dwyer Instruments, Inc.
2. Combination gage with low- and high-limit switches.
3. Nominal 4-inch-diameter analog indication with white dial face, graduated black markings, pointer to indicate measured value, and a separate adjustable pointer for each switch set point.
4. Switch zero and set-point tamperproof adjustment screws or knobs on the dial face.
5. Each switch used as a safety limit shall have a manual reset button local to switch.
6. Switch Type: Each set point shall have two Form C relays, DPDT.
7. Electrical Connections: Screw terminals.
8. Enclosure Conduit Connection: NPS 3/4 threaded connection.

9. High and Low Process Connections: Threaded, NPS 1/8.
10. Enclosure:
    a. Dry Indoor Installations: NEMA 250, Type 1.
    b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
    c. Hazardous Environments: Explosion proof.
11. Operating Data:
    a. Electrical Rating: 10 A at 120- to 240-V ac.
    b. Pressure Limits: 25 psig.
    c. Temperature Limits: 20 to 120 deg F.
    d. Operating Range: Approximately twice normal operating range unless otherwise required for application.
    e. Accuracy:
        1) 4 percent for ranges through 0.5 in. wg.
        2) 2 percent for ranges 1 in. wg and greater.
    f. Repeatability: Within 1 percent of full scale.
    g. Switch Deadband: One pointer width and within 1 percent of full scale for each switch set point.
    h. Power Supply: 24V ac, 50/60 Hz.
    i. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:
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. Setra System.
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 5 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.

B. Air-Pressure Differential Indicating Transmitter:
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. Dwyer Instruments, Inc.
2. Performance:
a. Range: Approximately 2 times set point.
b. Accuracy Including Hysteresis and Repeatability: Within 1 percent of full scale at 77 deg F.
c. Stability: Within 1 percent of full scale per year.
d. Overpressure: 10 psig.
e. Temperature Limits: 20 to 120 deg F.
f. Thermal Effects: 0.055 percent of full scale per degree F.
3. Display: Four-digit digital display with minimum 0.4-inch-high numeric characters.
4. Operator Interface:
a. Zero and span adjustments.
b. Selectable engineering units.
5. Analog Output Current Signal:
a. Two-wire, 4- to 20-mA dc current source.
b. Signal capable of operating into a 1200-ohm load.
6. Construction:
a. Plastic casing with clear plastic cover.
b. Integral fittings for plastic tubing connections on side of instrument case for high- and low-pressure connections.
c. Terminal block for wire connections.
d. Vertical plane mounting.
e. NEMA 250, Type 1.
f. Nominal 4-inch diameter face.
g. Mounting Bracket: Appropriate for installation.

C. Air-Pressure Differential Indicating Transmitter with Field-Selectable Features:
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. Dwyer Instruments, Inc.
2. Field-Selectable Features:
a. Field configurable for pressure and velocity applications through user interface.
b. Field selectable from one of three pressure ranges both in SI (metric) and inch-pound (IP) units of measure.
c. Select range based on application. Range shall be approximately 2 times set point.
3. Performance:
a. Accuracy Including Hysteresis and Repeatability:
1) Within 2 percent for 0.10 in. wg, 1.0 in. wg and all bi-directional ranges.

2) Within 1 percent for other ranges.
b. Stability: Within 1 percent of full scale per year.
c. Response Time: Adjustable 0.5- to 15-second time constant with 95 percent response within 1.5 to 45 seconds.
d. Overpressure: 1 psig maximum operating; 10 psig burst pressure.
e. Temperature Limits: Zero to 150 deg F.

4. Display: Four-digit digital display with minimum 0.4-inch-high numeric characters.
5. Operator Interface:
   a. Selectable pressure ranges, where indicated.
   b. Zero and span adjustments.
   c. Selectable air velocity mode with square root function.
   d. Adjustable signal dampening
6. Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into a 1200-ohm load.
7. Construction:
   a. Plastic casing with removable clear plastic cover.
   b. NPS 3/16 nominal ID plastic tubing connections on side of instrument case for high- and low-pressure connections.
   c. NPS 1/2 NPS threaded connection for conduit.
   d. Terminal block for wire connections.
   e. Vertical plane mounting.
   f. NEMA 250, Type 4X.
   g. Nominal 4-inch-diameter face.
   h. Mounting Bracket: Appropriate for installation.

D. Air-Pressure Differential Transmitter with 0.10 Percent Accuracy and Auto Zero Feature:
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. Air Monitor Corporation.
2. Description:
   a. 4- to 20-mA dc output signal.
   b. NEMA 250, Type 1 enclosure.
   c. Construct the assembly so that shock, vibration, and pressure surges of up to 1 psig will neither harm nor affect the accuracy of the transmitter.
   d. Transmitter with automatic zeroing circuit capable of automatically readjusting the transmitter to zero at predetermined time intervals. The automatic zeroing circuit shall re-zero the transmitter to within 0.1 percent of true zero.
   e. Performance:
      1) Range: Approximately 2 times set point.
      2) Calibrated Span: Field adjustable, minus 40 percent of the range.
      3) Accuracy: Within 0.10 percent of natural span.
      4) Repeatability: Within 0.15 percent of calibrated span.
      5) Linearity: Within 0.2 percent of calibrated span.
      6) Hysteresis and deadband (combined): Less than 0.2 percent of calibrated span.
   f. Integral digital display for continuous indication of pressure differential.

E. Air-Pressure Differential Indicating Transmitter, Switch, and Controller:

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. Dwyer Instruments, Inc.
2. Description:
   a. Three-in-one instrument, including digital display, control relay switches, and a transmitter with a current output.
   b. Field configurable for pressure, velocity, and volumetric flow applications through user interface.
   c. Select instrument range based on application. Range shall be approximately 2 times set point.
3. Performance:
   a. Accuracy Including Hysteresis and Repeatability:
      1) Within 1 percent for ranges less than 5 in. wg.
      2) Within 0.5 percent at 77 deg F for other ranges.
   b. Stability: Within 1 percent per year.
   c. Response Time: 250 ms.
   d. Overpressure: 5 psig for instrument ranges less than 50 in wg and 9 psig for 100 in. wg range.
   e. Temperature Limits: 32 to 140 deg F.
   f. Thermal Effects: 0.020 percent per degree F.
   g. Warm-up Period: One hour.
4. Controller Programming through Menu Keys to Access Five Menus:
   a. Security level.
   b. Pressure, velocity, or flow application.
   c. Engineering units.
   d. K-factor for use with flow application.
   e. Set-point control only; set-point and alarm operation; and alarm operation as high, low, or high/low with manual or automatic reset and delay.
   f. View high and low readings.
   g. Digital dampening for smoothing erratic applications.
   h. Scaling of analog output to fit range and field calibration.
5. Display:
   a. Digital, four-digit display with backlight, with 0.4-inch-high alphanumeric characters.
   b. Four indicators; two for set point and two for alarm status.
6. Operator Interface:
   a. Set-point adjustment through keypad on face of instrument.
   b. Zero and span adjustments accessible through menu.
   c. Programming through keypad.
7. Analog Output Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into a 900-ohm load.
8. Digital Output Signal:
   a. Two SPDT relays.
   b. Each rated for one amp at 30-V ac or dc.
9. Construction:
   a. Die cast-aluminum casing and bezel.
   b. Threaded, NPS 1/8 connections on side and back.
   c. Vertical plane mounting.
   d. NEMA 250, Type 1.

e. Nominal 4-inch-diameter face.
f. Mounting Bracket: Appropriate for installation.

2.5 LIQUID-PRESSURE SWITCHES

A. Liquid Gage Pressure Switch, Diaphragm Operated, Low Pressure:
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. Mercoid Controls: Dwyer Instruments, Inc.
2. Description:
a. Diaphragm operated to actuate an SPDT snap switch.
b. Electrical Connections: Screw terminal.
c. Enclosure Conduit Connection: Knock out or threaded connection.
d. User Interface: External screw with visual set-point adjustment.
e. Process Connection: Threaded, NPS 1/4.
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.
3. Operating Data:
a. Electrical Rating: 15 A at 120-V ac.
b. Pressure Limits:
1) Range 1 to 30 psig: 60 psig.
2) Range 10 to 125 psig: 160 psig.
c. Temperature Limits: Minus 30 to 150 deg F.
d. Operating Range: 10 to 250 psig.
e. Deadband: Fixed.
4. Pressure Chamber Material: Stainless steel.
5. Diaphragm Material: Nylon or PTFE.

B. Liquid Gage Pressure Switch-Diaphragm Operated:
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. Mercoid Controls: Dwyer Instruments, Inc.
2. Diaphragm operated to actuate a SPDT or DPDT snap switch.
3. Electrical Connections: Screw terminal.
4. Enclosure Conduit Connection: Knock out or threaded connection.
5. User Interface: Internal hex nut set-point adjustment with enclosed set-point indicator and scale.
a. Process Connection: Threaded, NPS 1/4 or NPS 1/2.
6. Enclosure:
a. Dry Indoor Installations: NEMA 250, Type 1, 12.
b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4X with drain.
c. Hazardous Environments: Explosion proof.
7. Operating Data:
a. Electrical Rating: 15 A at 120-, 240-, and 480-V ac.
b. Pressure Limits: 1200 psig.
c. Ambient Temperature Limits: Minus 30 to 180 deg F.

d. Process Temperature Limits: Minus 4 to 167 deg F.
e. Adjustable Operating Range: 10 to 150 psig.
f. Deadband: Adjustable.
8. Pressure Chamber Material stainless steel.
9. Diaphragm Material: Buna-N or fluorocarbon.

C. Liquid Gage Pressure Switch-Bourdon Tube Operated:
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. Dwyer Instruments, Inc.
2. Description:
a. Bourdon tube operated to actuate a SPDT snap switch.
b. Provide switches used in safety limiting applications with auto reset.
c. Wetted Materials: Type 403 stainless steel or Type 316 stainless steel.
d. Electrical Connections: Screw terminal.
e. Enclosure Conduit Connection: Knock out or threaded connection.
f. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
g. Process Connection: Threaded, NPS 1/4.
h. Enclosure:
1) Dry Indoor Installations: NEMA 250, Type 1.
2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
3) Hazardous Environments: Explosion proof.
i. Operating Data:
1) Electrical Rating: 5 A at 120-V ac.
2) Pressure Limits: Equal to maximum pressure in full-scale range, but not less than system design pressure rating.
3) Temperature Limits: 180 deg F.
4) Operating Range: Approximately 2 times set point, but not less than system design pressure rating.
5) Deadband: Adjustable or fixed as required by application.
j. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Liquid-Pressure Differential Switch with Set-Point Indicator:
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. Dwyer Instruments, Inc.
2. Description:
a. 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 or fixed as required by application.

E. Liquid-Pressure Differential Switch:
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. Ashcroft Inc.
2. Description:
a. Type 316 stainless-steel double opposing bellows operate to actuate an SPDT snap switch.
b. Wetted materials: Type 316 stainless steel.
c. Seal: Viton.
d. Electrical Connections: Screw terminal.
e. Enclosure Conduit Connection: Knock out or threaded connection.
f. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
g. High and Low Process Connections: Threaded, NPS 1/4.
h. Enclosure: NEMA 250, Type 4 or 4X.
i. Operating Data:
1) Electrical Rating: 10 A at 120- to 240-V ac.
2) Pressure Limits: Zero to 500 psig
3) Ambient Temperature Limits: Minus 20 to 150 deg F.
4) Process Temperature Limits: 20 to 300 deg F.
5) Operating Range: 2 times set point, unless otherwise required by application.
6) Deadband: Adjustable or fixed as required by application.
j. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 LIQUID-PRESSURE TRANSMITTERS

A. Liquid Gage Pressure Transmitter with Adjustable Span:
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. Rosemount; Emerson Process Management.
2. Performance:
a. Range: Minus 300 to 300 psig.
b. Span: Field adjustable.
c. Minimum Span: 3 psig.
d. Reference Accuracy: Within 0.07 percent of span or better.
e. Stability: Within 0.125 percent of upper range limit for 5 years.
f. Overpressure Limits: 3626 psig.

g. Process Temperature Limits: Minus 40 to 250 deg F.
h. Ambient Temperature Limits: Minus 40 to 185 deg F.
i. Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
j. Shock and vibration shall not harm the transmitter.

3. Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   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 aluminum or stainless steel.
   b. Enclosure with removable cover on each side.
   c. Wetted parts of transmitter constructed of Type 316 stainless steel.
   d. Threaded, NPS 1/2 process connection on bottom of instrument.
   e. Drain/vent valve on process connection.
   f. Two 1/2-inch trade size conduit connections on side of instrument enclosure.
   g. Screw terminal block for wire connections.
   h. NEMA 250, Type 4X.
   i. Mounting Bracket: Appropriate for installation.

B. Liquid-Pressure Differential Transmitter:
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. Dwyer Instruments, Inc.
2. Performance:
   a. Range: Approximately 2 times set point.
   b. Span: Adjustable plus or minus one milliamp, noninteractive.
   c. Accuracy: Within 0.25 percent of full scale.
   d. Pressure: Maximum operating pressure 2.5 times range.
   e. Temperature Limits: Zero to 175 deg F.
   f. Compensate Temperature Limits: 30 to 150 deg F.
   g. Thermal Effects: 0.02 percent of full scale per degree F.
   h. Response Time: 30 to 50 ms.
   i. Shock and vibration shall not harm the transmitter.
3. Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into 1000-ohm load.
4. Operator Interface:
   a. Zero and span adjustments located behind cover.
   b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.
5. Construction:
   a. Aluminum and stainless-steel enclosure with removable cover.
   b. Wetted parts of transmitter constructed of 17-4 PH or 300 Series stainless steel.
   c. Threaded, NPS 1/4 process connections on side of instrument enclosure.
   d. Knock out for 1/2-inch nominal conduit connection on side of instrument enclosure.

e. Screw terminal block for wire connections.
f. NEMA 250, Type 4X.
g. Mounting Bracket: Appropriate for installation.

C. Liquid-Pressure Differential Transmitter with Field-Selectable Range:
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. Dwyer Instruments, Inc.
2. Performance:
a. Field-Selectable Range:
1) 5, 10, 25, 50 psig.
2) 10, 20, 50, 100 psig.
3) 25, 50, 125, 250 psig.
b. Field-selectable unidirectional or bidirectional range.
c. Accuracy: Within 1 percent of the full-scale range, except lowest selectable range within 2 percent.
d. Stability: Within 0.5 percent of span per year.
e. Pressure: Maximum operating pressure equal to highest pressure in range.
f. Overpressure: Proof pressure 2.2 times full scale; burst pressure 40 times full scale.
g. Temperature Limits: Minus 44 to 185 deg F.
h. Compensate Temperature Limits: 32 to 130 deg F.
i. Thermal Effects: 2 percent of full scale per 100 deg F.
j. Response Time: Field selectable from 1 to 5 seconds.
k. Shock and vibration shall not harm the transmitter.
3. Configurable Analog Output Current Signal:
a. Two-wire, 4- to 20-mA dc current source.
b. Signal capable of operating into 1000-ohm load.
4. Configurable Analog Output Voltage Signals:
a. Three wire, zero to 5 V, zero to 10 V, and 1 to 5 V.
b. Minimum Load Resistance: 1000 ohms.
5. Display: Four-digit LCD with minimum 0.4-inch-high numeric characters.
6. Operator Interface:
a. Digital zero button located behind cover.
b. Range selector located behind cover.
7. Construction:
a. Cast-aluminum enclosure with removable cover.
b. Wetted parts of transmitter constructed of 17-4 PH stainless steel.
c. Threaded, NPS 1/8 process connections on bottom of instrument enclosure.
d. 1/2-inch trade size connection for conduit on bottom of instrument enclosure.
e. Screw terminal block for wire connections.
f. Vertical plane mounting.
g. NEMA 250, Type 4.
h. 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 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 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.

3.3 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 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 50 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] <Insert distance>; 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 1/2. 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 1/2. 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.

3.5 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 and on face of ceiling directly below instruments concealed above ceilings.

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 with respect to direction of flow, 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 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.

3.8 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.

3.9 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include monthly 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.

3.10 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of four (4) hours of instruction at the site, during start-up.
   3. Provide four (4) hours of instruction at the site after start-up
      a. Provide two (2) hours at three (3) months after start-up training
      b. Provide one (1) hour at six (6) months after start-up training.
      c. Provide one (1) hour at nine (9) months after start-up training

C. Coordinate pressure instrument demonstration 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 230923.23

SECTION 230923.27 - 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. Combination air temperature sensors and switches.
3. Air temperature switches.
4. Air temperature RTD transmitters.
5. Liquid temperature sensors.
6. High-end, commercial-grade, liquid temperature sensors.
7. Industrial-grade liquid and steam temperature sensors.
8. Liquid temperature switches.
9. High-end, commercial-grade, liquid, and steam temperature transmitters.
10. Industrial-grade liquid and steam temperature transmitters.

B. Related Requirements:
1. SECTION 230900 – INSTRUMENTATION AND CONTROL FOR HVAC
a. Control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

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.
5. 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:
   a. Product installation location shown in relationship to room, duct, pipe, and equipment.
   b. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
   c. Sizes and locations of wall access panels for instruments installed behind walls.
   d. Sizes and locations of ceiling access panels for instruments installed in inaccessible ceilings.

1.5 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[and cooled], 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 2.
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 1.
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

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. 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. Minco.
2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F
4. Probe: Single-point sensor with a stainless-steel sheath.
5. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
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: 3/4-inch

C. Platinum RTD, Air Temperature Averaging Sensors:

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. Minco.
2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F
4. Multiple sensors to provide average temperature across entire length of sensor.
5. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
6. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
7. Length: As required by application to cover entire cross section of air tunnel.
8. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
9. Gasket for attachment to duct or equipment to seal penetration airtight.
10. Conduit Connection: 3/4-inch

D. Platinum RTD Outdoor Air Temperature Sensors:
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. Minco.
2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F
4. Probe: Single-point sensor with a stainless-steel sheath.
5. Solar Shield: Stainless steel.
6. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
7. Conduit Connection: 3/4-inch trade size.

E. Platinum RTD Space Air Temperature Sensors:
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. Minco.
2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 212 deg F
4. Sensor assembly shall include a temperature sensing element mounted under a flush, brushed-aluminum cover.
5. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
6. Concealed wiring connection.

F. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units
1. 100- or 1000 ohm platinum RTD or thermistor.
2. 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.
3. 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.

4. Provide digital display of sensed temperature.
5. Provide sensor with local control.
   a. Local override to turn HVAC on.
   b. Local adjustment of temperature set point.
   c. Both features shall be capable of manual override through control system operator.

G. 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.

H. Thermistor, Single-Point Duct Air Temperature Sensors:
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. Minco.
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: 3/4- inch trade size.

I. Thermistor Averaging Air Temperature Sensors:
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. Minco.
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: 3/4-inch trade size.

J. Thermistor Outdoor Air Temperature Sensors:

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. Minco.
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: 3/4-inch trade size.

2.3 COMBINATION AIR TEMPERATURE SENSOR AND SWITCH

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. Minco.

B. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

C. Combination temperature sensor and switch in same instrument.

D. Air Temperature Switch:
   1. Factory preset set point of 38 deg F. Field-adjustable set point from 30 to 44 deg F.
   2. Responsive to coldest 12-inch section of sensor length.
   3. DPST latching relay rated at 25 A and 120-V ac, with powered controller, coil, and manual rest at panel. Wire one leg to fan start circuit and other leg to signal a remote alarm.

E. Air Temperature Sensor:
   1. Temperature-averaging type over sensor length. Length to be determined by installing trade to provide uniform coverage over air tunnel. Consult manufacturer for recommendations.
   2. Platinum RTD with a value of 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
   3. Accuracy: Within 0.9 deg F.
   4. Output Signal: 4 to 20 mA for connection to remote monitoring.
   5. Encase RTDs in a flexible nominal 0.375-inch-diameter sheath constructed of brass.
   6. Lead wires shall be 18-gage AWG copper.
   7. Enclosure: NEMA 250, Type 4.

2.4 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:
   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. Honeywell International Inc.
      b. Siemens Industry, Inc. (Building Technologies Division).

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. 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-inchsection along element length.
4. Construction:
   a. Vapor-Filled Sensing Element: Nominal 20 feetlong.
   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.

2.5 AIR TEMPERATURE RTD TRANSMITTERS

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. Minco.

B. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

C. House electronics in NEMA 250 enclosure.
   1. Duct: Type 3.
   2. Outdoor: Type 4 or Type 4X.
   3. Space: Type 1.

D. Conduit Connection: 1/2-inch

E. Functional Characteristics:
   1. Input:
      a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
      b. 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.

F. 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.

2.6 LIQUID TEMPERATURE SENSORS, COMMERCIAL GRADE

A. RTD:
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. MAMAC Systems, Inc.
2. Description:
a. Platinum with a value of 100 or 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 inches as 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. 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. MAMAC Systems, Inc.
2. Stem: Straight or stepped shank formed from solid bar stock.
3. Material: stainless steel.
4. Process Connection: Threaded, NPS 3/4.
5. Sensor Connection: Threaded, NPS 1/2.
6. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
7. Furnish thermowells installed in insulated pipes and equipment with an extended neck.
8. Length: 4, 6, or 8 inches as required by application.
9. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

2.7 LIQUID TEMPERATURE SENSORS, HIGH-END COMMERCIAL GRADE

A. RTD:
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. Minco.
2. Resistance temperature sensors shall comply with IEC 60751, Class B requirements.
3. Platinum with a value of 100 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
4. Encase RTD in a Type 316 stainless-steel sheath with a 0.25-inch OD.
5. Provide four-wire, PTFE-insulated, nickel-coated, 22-gage, stranded copper leads.
6. Provide spring-loaded RTDs for thermowell installations.
7. Performance Characteristics:
   a. Range: Minus 328 to 932 deg F.
   b. Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.
   c. Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at 752 deg F.
   d. Hysteresis: Within 0.04 percent of range.
   e. Response Time: 62.8 percent of change in 4 seconds with water flowing across sensor at 3 fps.

B. Thermowells:
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. Minco.
2. Stem: Straight or stepped or tapered shank formed from solid bar stock.
3. Material: Type 304 or Type 316 stainless steel.
4. Process Connection: Threaded, NPS 3/4
5. Sensor Connection: Threaded, NPS 1/2
6. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
7. Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends beyond the face of the insulation covering.
8. Length: As required by application and pipe size.
9. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

C. Connection Heads:
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. Minco.
2. Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.
3. Terminals: Six or eight as required by sensor.
4. Conduit Connection: 1/2-inch trade size.
5. Sensor Connection: NPS 1/2.

D. Assembly: Sensor manufacturer shall furnish sensor, thermowell, and sensor connection head to provide a matched assembly.

2.8 LIQUID TEMPERATURE SWITCHES

A. Thermostat and Switch for Temperature Control in Pipe Applications:
   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. Honeywell International Inc.
   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. 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.
   4. Construction:
      a. Vapor-Filled Immersion Element: Copper, nominal 3 inches long.
      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.

2.9 LIQUID TEMPERATURE TRANSMITTERS, COMMERCIAL GRADE

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. Minco.

B. House electronics in NEMA 250, Type 4 or Type 4X enclosure.

C. Enclosure Connection: 1/2-inch trade size.

D. Functional Characteristics:
   1. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two- or three-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.

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.

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: Thermistor, 1000-ohm platinum RTD.
2. Outdoor: Thermistor, 1000-ohm platinum RTD
3. Space
   a. General: Thermistor 1000-ohm platinum RTD.

B. Air Temperature Transmitters:
1. Duct: Not required.
2. Outdoor: Not required.
3. Space: Not required.

C. Liquid Temperature Sensors:
1. Liquid and steam temperature sensor, commercial grade.

D. Liquid and Temperature Transmitters:
1. Liquid and steam temperature transmitter, commercial grade.

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 a <Insert value> 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. Button sensors install on ceiling of the bedrooms

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 service platform or catwalk.

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 and on face of ceiling directly below instruments concealed above ceilings.

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 with the assistance of a factory-authorized service representative:
   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 12 months' full maintenance by manufacturer's authorized service representative. Include monthly 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 AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.

B. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of four (4) hours of instruction at the site, during start-up.
   3. Provide four (4) hours of instruction at the site after start-up
      a. Provide two (2) hours at three (3) months after start-up training
      b. Provide one (1) hour at six (6) months after start-up training.
      c. Provide one (1) hour at nine (9) months after start-up training

C. 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.

D. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

E. Record videos on DVD disks.

F. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.27

SECTION 232113 - 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. Hot-water heating piping.
   4. High temperature piping.
   5. Makeup-water piping
   6. Unions and Flanges
   7. Dielectric fittings.
   8. Joint Materials
   9. Air-vent piping.
   10. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Pipe.
   2. Fittings.
   3. Grooved joint piping system
   4. Pressure-seal fittings.

B. Shop Drawings: Detail, at 1/4”=1’-0” scale, the piping layout, fabrication of pipe hangers, supports for multiple pipes and attachments of the same to the building structure.

C. 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.
   4. Qualification Data: For Installer.
   5. Welding certificates.

D. Welder’s certificates. Certification shall be in accordance with ANSI/ASME Section 9. Submit Welding Procedure Specification (WPS) and Welder Performance Qualification (WPQ).

E. Qualification Data: For Installer.

F. Piping and fittings shall fully comply with the most current ASTM, ANSI and ASME standards.

G. Preconstruction Test Reports:
1. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.4 QUALITY ASSURANCE

A. Installer Qualifications:
1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

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.

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation of heating water piping systems. 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 01. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation for HTHW piping systems.

1.5 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on water quality.

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. Cooling-Water Piping: 150 psig at 150 deg F.
3. High Temp Hot water heating piping 400 psig at 400 deg F
4. Glycol Condenser-Water Piping: 150 psig at 73 deg F.
5. Makeup-Water Piping: 80 psig at 73 deg F.
6. Air-Vent Piping: 180 deg F.

7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.
8. Condensate drain piping

2.2 COPPER TUBE AND FITTINGS

A. Line size 1/2" to 2” Copper:
   1. Pipe: Seamless, hard-drawn Type L copper tubing, ASTM B88.
   2. Fittings shall be either of the following:
      a. Wrought-copper fittings, and soldered joints.
         1) Fittings: ANSI/ASME B16.18 cast copper, or ANSI/ASME B16.22 wrought copper.
         2) Joints: ANSI/ASME B32 solder Grade 95TA.
      b. Copper or Bronze Pressure-Seal Fittings:
         1) Housing: Copper.
         2) O-Rings and Pipe Stops: EPDM.
         3) Tools: Manufacturer's special tools.
         4) Minimum 200-psig working-pressure rating at 250 deg F.

B. Grooved, Mechanical-Joint, Wrought-Copper Fittings:
   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. Anvil International.
      b. Grinnell G-Fire by Johnson Controls Company.
      c. Victaulic Company
   2. 2"-8" for copper tubing consisting of ductile iron cast housings, complete with a synthetic rubber gasket of a pressure-responsive design, with plated nuts and bolts to secure unit together.
      a. Couplings shall be manufactured to connect copper tubing sized tube and fittings.
      b. Ductile iron housings conforming to ASTM A-536, Grade 65-45-12, coated with copper colored alkyd enamel.
      c. Housings cast with offsetting, angle-pattern bolt pads to provide rigidity.
      d. Gasket shall be Grade “EHP” EPDM compound with red color code designed for operating temperatures from -30°F to +250°F.
      e. Basis of Design: Victaulic 607
   3. Butterfly Valves: 2-1/2" - 6", 300 psi maximum pressure rating, with copper tubing sized grooved ends. Cast brass body to UNS C87850. Aluminum bronze disc to UNS C95500, with pressure responsive elastomer seat. Stem shall be offset from the disc centerline to provide complete 360-degree circumferential seating. Bubble tight, dead-end or bi-directional service, with memory stop for throttling, metering or balancing service. Valve may be automated with electric, pneumatic, or hydraulic operators. Certified to the low lead requirements of NSF-372. Victaulic Series 608N.

C. Copper Pressure-Seal-Joint Fittings:
   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. Elkhart Products Corporation.
      b. NIBCO Inc.

c. Viega.
2. Fittings for NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
3. Fittings for NPS 2-1/2 to NPS 4: NOT ALLOWED

D. Wrought-Copper Unions: ASME B16.22.

E. TEE FITTINGS
1. Provide FULL SIZE TEE fittings for all piping materials and joining methods.

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. Line size from 1/2” to 2” Steel:
1. Pipe: Schedule 40 black ERW carbon steel pipe, ASTM A53 Grade A or Grade B.
2. Fittings: ASTM A234 forged steel, Class 125 threaded or Grooved.
3. Joints: ANSI/AWS D1.1 Threaded or grooved joints.

C. Line size from 2-1/2” to 4” Steel:
1. Pipe: Schedule 40 black ERW carbon steel pipe, ASTM A53 Grade A or Grade B.
2. Fittings: ASTM A234 forged steel, Class 125 welding type or Grooved.
3. Joints: ANSI/AWS D1.1 welded, flanged or grooved joints. Flanges shall be Class 150 weld neck with ASTM A193-B7 bolts with ASTM A194-2H nuts.

D. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

E. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

F. 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.

G. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

H. 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.

I. Grooved Mechanical-Joint Fittings and Couplings:
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. Anvil International.
b. Grinnell G-Fire by Johnson Controls Company.
c. Victaulic Company

2. Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. Mechanical Coupling bolts shall be zinc plated heat-treated carbon steel track head conforming to ASTM A-449 and, minimum tensile strength 110,000 psi.
   a. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1 Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM compound with red and green color code designed for operating temperatures from -30° F to +250° F. Basis of design: Victaulic S/107N, S/W07
   b. Flexible Type: Use in locations where vibration attenuation and thermal expansion compensation. Riser piping shall use linear movement of couplings with A10 anchors. Installation ready flexible coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM compound with red and green color code designed for operating temperatures from -30° F to +250° F. Basis of Design: Victaulic S/177N S/W77
   c. Victaulic Floor-Mounted Riser Anchor: Engineered pipe anchor, sizes 2" through 12"; to assist in directing pipe movement in piping system risers that are designed and installed with approved Victaulic products. Standard weight carbon steel to ASTM A53 with orange enamel coating, with carbon steel brackets. Victaulic Original-Groove System grooved ends. Anchors suitable for system operating pressure to 500-psi. Basis of Design: Victaulic No. A10.
   d. Plain-End Carbon Steel Connections: ½" – 2" Plain End Joints: Installation-Ready fittings for Schedule 40 carbon steel piping in HVAC and mechanical applications. System rated for a working pressure of 300 psi. Fittings shall consist of a ductile iron housing conforming to ASTM A536, Grade 65-45-12, with Installation-Ready ends orange enamel coated. Fittings complete with gasket liner, zinc-electroplated steel bolts and nuts as per the mechanical properties of ASTM A449, and 300 series stainless steel retainer.

J. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 HIGH TEMPERATURE HOT WATER PIPING (400°F)

A. HTHW Heating Water Piping (400 Deg.)
   1. Steel 3" & smaller:
      a. ASTM A53 or A106, Grade B Sch. 80 steel - with ASTM A105, 3000-pound socket weld steel fittings.
   2. Steel 1-1/2" & larger:
      a. ASTM A53 or A106, Grade A or B, Sch. 80 seamless steel with ASTM A105 3000 pound butt weld steel fittings.
   3. **Joints: Flanged or welded per ASME B31.1. <u>Threaded joints are not allowed</u>.**
   4. Equipment Valve Connection: Flanged or welded. Threaded joints are not allowed.

B. Gaskets:
   1. 1/8" full face - punched Garlock Blueguard (minimum 600 LB) or equal as approved by Engineer.
   2. No asbestos containing materials allowed.

C. Bo lts:
   a. Grade B7 chrome moly A193 with 2H nuts.
   b. Bolt length selection must allow for a full nut plus a maximum of 1/2" of thread. Studs are not allowed.

2.5 AIR VENT PIPING:

A. All sizes:

1. Pipe: Schedule 40 seamless black carbon steel, ASTM A53 Grade B, or Schedule 40 seamless black carbon steel, ASTM A106 Grade B.

2. Fittings: Threaded - ASTM B16.3 malleable iron, Class 125, or ASTM A234 forged steel Class 125. Welded - ASTM A234 forged steel, Class 125 welding type.

3. Joints: Threaded or welded.

2.6 EQUIPMENT CONDENSATE LINES:

A. Line size to 3”:

1. Pipe: ASTM B88 Type DWV hard drawn copper tubing, or ASTM D1785 Schedule 40 PVC piping.

2. Fittings: ANSI/ASME B16.18 cast copper or ANSI/ASME B16.22 wrought copper; ASTM D2466 Schedule 40 PVC.

3. Joints: ASTM B32 solder Grade 95TA; ASTM D2855 solvent weld with ASTM D2564 solvent cement.

2.7 UNIONS AND FLANGES:

A. Heating Water Dielectric Unions: HEATING WATER (TO 220°F)

1. General Requirements: Assembly of copper alloy and ferrous materials with separating non-conductive insulating material. Include end connections compatible with pipes to be joined

2. Acceptable manufacturers:
   a) Hart Industries International, Inc.
   b) Jomar International Ltd.
   c) Matco-Norca, Inc.
   d) Watts Regulator Co.

3. Description:
   a) Union with galvanized or plated steel threaded end and copper solder end, with impervious isolation barrier.
   b) Pressure Rating: 250 psig @ 180^0F.

B. Heating Water Unions:

1. Ferrous Piping: Class 150, malleable iron, threaded.

2. Copper Piping: Class 150, bronze unions with soldered or brazed joints.

C. Flanges:

1. Description: For ferrous piping 2-1/2 inches and larger, Class 150 forged steel, slip-on or weld-neck flanges.

D. High Temperature Hot Water System Flanges

1. ASTM A105, Class 300 slip-on or weld neck raised faced.

2.8 GROOVED JOINTS (not to be used above 250°F water)

A. Grooved Mechanical-Joint Fittings and Couplings: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. Mechanical Coupling bolts shall be zinc plated heat treated carbon steel track head conforming to ASTM A-449 and, minimum tensile strength 110,000 psi.

1. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13. Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM compound with red color code designed for operating temperatures from -30 deg F to +250 deg F. Basis of design: Victaulic S/107N, S/W07
2. Flexible Type: Use in locations where vibration attenuation and thermal expansion compensation are required (including risers). Installation ready flexible coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM compound with red color code designed for operating temperatures from -30 deg F to +250 deg F. Basis of Design: Victaulic S/177N S/W77
3. ½" – 2" Plain End Joints: Installation-Ready fittings for Schedule 40 carbon steel piping in HVAC and mechanical applications. System rated for a working pressure of 300 psi. Fittings shall consist of a ductile iron housing conforming to ASTM A536, Grade 65-45-12, with Installation-Ready ends orange enamel coated. Fittings complete with gasket liner, zinc-electroplated steel bolts and nuts as per the mechanical properties of ASTM A449, and 300 series stainless steel retainer.

2.9 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. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. 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.

E. 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.

2.10 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 Flanges:
   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. Matco-Norca.
      b. WATTS.
      c. Wilkins.
      d. Zurn Industries, LLC.
   2. Description:
      a. Standard: ASSE 1079.
      b. Factory-fabricated, bolted, companion-flange assembly.
      c. Pressure Rating: 125 psig minimum at 180 deg F.
      d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

C. Dielectric-Flange Insulating Kits:
   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. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.
   2. Description:
      a. Nonconducting materials for field assembly of companion flanges.
      b. Pressure Rating: 150 psig.
      c. Gasket: Neoprene or phenolic.
      d. Bolt Sleeves: Phenolic or polyethylene.
      e. Washers: Phenolic with steel backing washers.

D. Dielectric Nipples:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Grinnell G-Fire by Johnson Controls Company.
      b. Matco-Norca.
      c. Precision Plumbing Products.
      d. 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.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. All piping and associated fittings shall have pressure and temperature ratings in excess of the operating temperature and pressure of the hydronic system. In general, the minimum working pressure shall be 150 psig unless the specific design requires a higher rating.

B. Heating-Water Piping, Aboveground, NPS 2 and smaller, shall be any of the following:
1. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
   a. Up to 2" above grade piping: Malleable iron, threaded.
2. Type L hard drawn copper tubing, Solder joints and fittings. Copper Pipe Fittings and Joining Methods:
   a. Cast or wrought copper.
   b. Solder Joint: Wrought copper.
   c. Solder: 95-5 (95% tin, 5% antimony).
   d. Brazing: Brazing filler metal (silver or copper phosphorous).
   e. Lead Solder is not permitted.
   f. Pressure-Seal-Joint Fittings (hydraulically crimped fittings).

C. Heating-Water Piping, Aboveground, NPS 2-1/2 and larger, shall be any of the following:
1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints. Refer to 3.6-H of this section.
3. Steel Pipe Fittings and Joining Methods:
   a. 2-1/2" and over and all below grade piping: Socket welded, or butt welded
   b. Welding: The project specifications shall require the contractor to submit the following information for review prior to the commencement of the work.
      1) Welding procedures conforming to ANSI B31.1 and ANSI Z49-1.
      2) A list of welders qualified per Section IX of ASME Boiler and Pressure Vessel Code.
      3) Copies of welder’s certification.
4. Type L hard drawn copper tubing, Solder joints and fittings. Copper Pipe Fittings and Joining Methods:
   a. Cast or wrought copper.
   b. Solder Joint: Wrought copper.
   c. Solder: 95-5 (95% tin, 5% antimony).
   d. Brazing: Brazing filler metal (silver or copper phosphorous).
   e. Lead Solder is not permitted.
   f. Pressure-Seal-Joint Fittings (hydraulically crimped fittings) not permitted for this pipe size.

D. Cooling-Water Piping, Aboveground, NPS 2 and smaller, shall be any of the following:
1. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
   a. Up to 2" above grade piping: Malleable iron, threaded.
2. Type L hard drawn copper tubing, Solder joints and fittings. Copper Pipe Fittings and Joining Methods:

a. Cast or wrought copper.
b. Solder Joint: Wrought copper.
c. Solder: 95-5 (95% tin, 5% antimony).
d. Brazing: Brazing filler metal (silver or copper phosphorous).
e. Lead Solder is not permitted.
f. Pressure-Seal-Joint Fittings (hydraulically crimped fittings).

E. Cooling-Water Piping, Aboveground, NPS 2-1/2 and larger, shall be any of the following:
1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints. Refer to 3.6-H of this section.
3. Steel Pipe Fittings and Joining Methods:
   a. 2-1/2" and over and all below grade piping: Socket welded, or butt welded
   b. Welding: The project specifications shall require the contractor to submit the following information for review prior to the commencement of the work.
      1) Welding procedures conforming to ANSI B31.1 and ANSI Z49-1.
      2) A list of welders qualified per Section IX of ASME Boiler and Pressure Vessel Code.
      3) Copies of welder's certification.
4. Type L hard drawn copper tubing, Solder joints and fittings. Copper Pipe Fittings and Joining Methods:
   a. Cast or wrought copper.
   b. Solder Joint: Wrought copper.
   c. Solder: 95-5 (95% tin, 5% antimony).
   d. Brazing: Brazing filler metal (silver or copper phosphorous).
   e. Lead Solder is not permitted.
   f. Pressure-Seal-Joint Fittings (hydraulically crimped fittings) not permitted for this pipe size.

F. Glycol Condenser-Water Piping, Aboveground, NPS 2 and smaller, shall be any of the following:
1. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
   a. Up to 2" above grade piping: Malleable iron, threaded.
2. Type L hard drawn copper tubing, Solder joints and fittings. Copper Pipe Fittings and Joining Methods:
   a. Cast or wrought copper.
   b. Solder Joint: Wrought copper.
   c. Solder: 95-5 (95% tin, 5% antimony).
   d. Brazing: Brazing filler metal (silver or copper phosphorous).
   e. Lead Solder is not permitted.
   f. Pressure-Seal-Joint Fittings (hydraulically crimped fittings).

G. Glycol Condenser-Water Piping, Aboveground, NPS 2-1/2 and larger, shall be any of the following:
1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints. Refer to 3.6-H of this section.
3. Steel Pipe Fittings and Joining Methods:

a. 2-1/2" and over and all below grade piping: Socket welded, or butt welded
b. Welding: The project specifications shall require the contractor to submit the following information for review prior to the commencement of the work.
1) Welding procedures conforming to ANSI B31.1 and ANSI Z49-1.
2) A list of welders qualified per Section IX of ASME Boiler and Pressure Vessel Code.
3) Copies of welder's certification.

4. Type L hard drawn copper tubing, Solder joints and fittings. Copper Pipe Fittings and Joining Methods:
a. Cast or wrought copper.
b. Solder Joint: Wrought copper.
c. Solder: 95-5 (95% tin, 5% antimony).
d. Brazing: Brazing filler metal (silver or copper phosphorous).
e. Lead Solder is not permitted.
f. Pressure-Seal-Joint Fittings (hydraulically crimped fittings) not permitted for this pipe size.

H. High Temperature Hot-water (HTHW) piping, aboveground, shall be the following:
1. Steel 1-1/4" & smaller: ASTM A53 or A106, Grade B Sch. 80 steel - with ASTM A105, 3000-pound socket weld steel fittings. (THREADED JOINTS NOT ALLOWED)
2. Steel 1-1/2" & larger: ASTM A53 or A106, Grade A or B, Sch. 80 seamless steel with ASTM A105 3000 pound butt weld steel fittings. (THREADED JOINTS NOT ALLOWED

I. Makeup-Water Piping, Aboveground, NPS 2 and smaller, shall be any of the following:
1. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
a. Up to 2" above grade piping: Malleable iron, threaded.
2. Type L hard drawn copper tubing, Solder joints and fittings. Copper Pipe Fittings and Joining Methods:
a. Cast or wrought copper.
b. Solder Joint: Wrought copper.
c. Solder: 95-5 (95% tin, 5% antimony).
d. Brazing: Brazing filler metal (silver or copper phosphorous).
e. Lead Solder is not permitted.
f. Pressure-Seal-Joint Fittings (hydraulically crimped fittings).

J. Makeup-Water Piping, Aboveground, NPS 2-1/2 and larger, shall be any of the following:
1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints. Refer to 3.6-H of this section.
3. Steel Pipe Fittings and Joining Methods:
a. 2-1/2" and over and all below grade piping: Socket welded, or butt welded
b. Welding: The project specifications shall require the contractor to submit the following information for review prior to the commencement of the work.
1) Welding procedures conforming to ANSI B31.1 and ANSI Z49-1.
2) A list of welders qualified per Section IX of ASME Boiler and Pressure Vessel Code.
3) Copies of welder's certification.

4. Type L hard drawn copper tubing, Solder joints and fittings. Copper Pipe Fittings and Joining Methods:

a. Cast or wrought copper.
b. Solder Joint: Wrought copper.
c. Solder: 95-5 (95% tin, 5% antimony).
d. Brazing: Brazing filler metal (silver or copper phosphorous).
e. Lead Solder is not permitted.
f. Pressure-Seal-Joint Fittings (hydraulically crimped fittings) not permitted for this pipe size.

K. Condensate-Drain Piping: Type L,
1. Drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 PVC with solvent joints

L. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

M. Air-Vent Piping: Same materials and joining methods as for piping specified for the service in which the air vent is installed.

N. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

O. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer

3.2 PIPING REQUIREMENTS

A. Provide shutoff/isolation valves in the following locations:
1. At each terminal unit and equipment connection.
2. At each riser serving two or more terminal units.
3. At each sub-main.
4. At each branch takeoff serving two or more terminal units.

B. Provide air vents at all high points in the hydronic system and at all terminal units.

C. Piping systems shall be provided with drains at all low points in the system, at the base of each riser, and at all terminal units and other equipment to allow the system to be fully drained.

D. Provide dielectric fittings or bronze valves at the connections of dissimilar materials.

E. Equipment condensate drain piping, including the trap dimensions, shall be in accordance with the equipment manufacturer’s installation instructions.

F. Provide balancing valves with integral read out ports and memory stops at all terminal unit and equipment connections and at all sub-mains and branches containing two or more terminal units for system balancing.

G. Place valves above accessible ceilings or in open areas to avoid the need for access panels

H. All piping and associated fittings shall have pressure and temperature ratings in excess of the operating temperature and pressure of the hydronic system. In general, the minimum working pressure shall be 150 psig unless the specific design requires a higher rating.

I. Welding: The project specifications shall require the contractor to submit the following information for review prior to the commencement of the work.
   1. Welding procedures conforming to ANSI B31.1 and ANSI Z49-1.
   2. A list of welders qualified per Section IX of ASME Boiler and Pressure Vessel Code.
   3. Copies of welder's certification.

J. Pressure-Sealed Joints for Copper Tubing up to 2" and Grooved Piping systems for hot and cold domestic water and low temp heating supply and return water.

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 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 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.

M. Install strainers with drains, consisting of a 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.

N. For all equipment install drains, consisting of a 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.

O. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

P. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

Q. Install branch connections to mains using 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.

R. Install valves according to the following:
1. Section 230523.12 "Ball Valves for HVAC Piping."
2. Section 230523.13 "Butterfly Valves for HVAC Piping."
3. Section 230523.14 "Check Valves for HVAC Piping."
4. Section 230523.15 "Gate Valves for HVAC Piping."

S. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

T. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

U. Install shutoff valve immediately upstream of each dielectric fitting.

V. 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.

W. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

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 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 flanges or flange kits.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 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 and 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.

3.6 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. Grooved Joints: Pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing. The gasket style and elastomeric material shall be verified as suitable for the intended service as specified. Flexible couplings only to be used for expansion loops, pump trim and were approved by the engineer. A factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation. A Victaulic representative shall periodically visit the job site and review installation.
   1. Grooved piping installation shall be inspected and verified by the factory representative to confirm proper installation procedures are employed. Factory representative shall
      a. Inspect the pipe groves for proper circumference, depth, and machining.
      b. Confirm applications of rigid and flexible couplings.
      c. Confirm proper pipe support for the associated couplings.
      d. Provide a report after each site visit to the construction manager.
   2. The grooved piping products manufacturer will provide piping system design services to accommodate thermal movement, seismic movement, and for the settlement of the piping system. The service includes required grooved piping components detailed in CAD on an overlay of the mechanical contract drawings, including anchor load calculations and placement of anchors. A calculation report showing thermal movement and accommodation shall also be provided. A design stamped by a qualified professional engineer from the jurisdiction in which the grooved piping products manufacturer is located or where the project is being constructed is required.

I. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

J. Provide Owner with Two (2) Pressure-Sealed Joints / fittings tool for each manufacture used on the project.

K. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

3.7 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."

3.8 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 or 100 PSI minimum. 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 15 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.

3.9 FIELD QUALITY CONTROL - HTHW

A. Prepare HTHW piping according to ASME B31.1 and as follows:
   1. Refer to Division 01 4000 Quality Requirements, 2015 Building Code of NYS Statement of Special Inspection, item R4, for radiological testing of HTHW welds by a special inspector.
   2. Leave joints, including welds, uninsulated and exposed for examination during test. 100% of welds shall be visually inspected by an ASME certified welding inspector, 100% of welds shall be radiologically tested. If any of these weld joints are found unacceptable, they shall be repaired and respected. Testing shall be provided by DASNY for radiologically work by a third party.
   3. Flush HTHW piping 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.

B. Refer to section 23 05 00 for testing requirements on hydronic piping.

END OF SECTION 232113

SECTION 232116 - 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. Expansion tanks and fittings.
4. Strainers.
5. Connectors.
6. Calibrated flow balancing valves.
7. Water pressure safety relief valves.
8. Water pressure reducing valves.
9. Backflow preventers.
10. Water line strainers.

B. Related Requirements:
1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
2. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
3. Section 230523.13 "Butterfly Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.
4. Section 230523.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
5. Section 230523.15 "Gate Valves for HVAC Piping" for specification and installation requirements for gate valves common to most piping systems.
6. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.3 REFERENCES

A. ASME – American Society of Mechanical Engineers.

B. ANSI – American National Standards Institute.

C. ISO – International Standards Organization.

1.4 DEFINITIONS

A. AWS: American Welding Society.

B. ASSE: American Society of Sanitation Engineers.

C. ASME: American Society of Mechanical Engineers.

D. AWS: American Welding Society

1.5 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.
4. Welding certification: In accordance with ANSI/ASME Section 9.
5. Qualification Data: For Installer.
6. Piping and fittings shall fully comply with the most current ASTM, ANSI and ASME standards

B. Shop Drawings: Detail, at 1/4” = 1’-0” scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.
1. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.7 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.

C. The product manufacturer shall be fully certified by the International Standards Organization per ISO 9001.

D. The manufacturer shall carry a minimum product liability insurance of $5,000,000.00 per occurrence.

E. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

F. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. 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 01.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves: Up to 1-1/2":
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. Tour & Anderson
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett; a Xylem brand.
   d. Flow Design, Inc.
   e. Griswold Controls.
2. Basis of design, TA Series STAD Balancing valves with provision for connecting a portable differential (Ft. of Head) pressure meter. Each meter connection shall have pressure/temperature probes.
3. The balancing valves shall be Y-pattern globe style design with ductile iron body all other wetted parts of nonferrous, pressure die cast Ametal. Each valve shall provide three (3) functions:
   a. (1) Precision flow measurement,
   b. (2) Precision flow balancing,
   c. (3) Shut-off feature,
4. Valves shall have eight (8), twelve (12), sixteen (16) or twenty-two (22) 360° adjustment turns of the handwheel for precise setting with hidden memory feature to program the valve with precision tamper-proof balancing setting. Handwheel shall have digital readout.
5. The handwheel can be installed in any position without affecting performance.
6. Ball: stainless steel.
7. Disc: Glass and carbon-filled PTFE.
8. Seat seal: Stem with EPDM O-ring
9. Spindle seal: EPDM O-ring
10. Handwheel: Polyamide
11. Smooth ends:
12. Nipple: AMETAL®
13. Sealing (DN 25-50): EPDM O-ringSeat: PTFE.
14. End Connections: Flanged or grooved (cooling only).
15. Pressure Gage Connections: Integral seals for portable differential pressure meter.
16. CWP Rating: Minimum 125 psig.

17. Maximum Operating Temperature: 250 deg F.

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves 2" and larger:
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. Tour & Anderson
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett; a Xylem brand.
   d. Flow Design, Inc.
   e. Griswold Controls.
2. Basis of design, TA Series 788/789 Balancing valves with provision for connecting a portable differential (Ft. of Head) pressure meter. Each meter connection shall have pressure/temperature probes.
3. The balancing valves shall be Y-pattern globe style design with ductile iron body all other wetted parts of nonferrous, pressure die cast Ametal. Each valve shall provide three (3) functions:
   a. (1) Precision flow measurement,
   b. (2) Precision flow balancing,
   c. (3) Shut-off feature,
4. Valves shall have twelve (12), sixteen (16) or twenty-two (22) 360° adjustment turns of the handwheel for precise setting with hidden memory feature to program the valve with precision tamper-proof balancing setting. Handwheel shall have digital readout.
5. The handwheel can be installed in any position without affecting performance.
6. Ball: stainless steel.
7. Stem Seals: EPDM O-rings.
8. Disc: Glass and carbon-filled PTFE.
9. Seat: PTFE.
10. End Connections: Flanged or grooved (cooling only).
11. Pressure Gage Connections: Integral seals for portable differential pressure meter.
12. CWP Rating: Minimum 125 psig.
13. Maximum Operating Temperature: 250 deg F.

C. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
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. Armstrong Pumps, Inc.
   b. Bell & Gossett; a Xylem brand.
   c. WATTS.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

D. Diaphragm-Operated Safety Valves: ASME labeled.
   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. Armstrong Pumps, Inc.
      b. Bell & Gossett; a Xylem brand.
      c. WATTS.
   2. Body: Bronze or brass.
   3. Disc: Glass and carbon-filled PTFE.
   4. Seat: Brass.
   5. Stem Seals: EPDM O-rings.
   6. Diaphragm: EPT.
   7. Wetted, Internal Work Parts: Brass and rubber.
   8. Inlet Strainer: stainless steel, removable without system shutdown.
   9. Valve Seat and Stem: Noncorrosive.
   10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Automatic Flow-Control Valves.
   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. Flow Design, Inc.
      b. Griswold Controls.
      c. NuTech Hydronic Specialty Products.
      d. WATTS.
   2. Body: Brass or ferrous metal.
   3. Flow Control Assembly, provide either of the following:
      a. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
      b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig differential pressure.
   4. Combination Assemblies: Include bronze or brass-alloy ball valve.
   5. Identification Tag: Marked with zone identification, valve number, and flow rate.
   6. Size: Same as pipe in which installed.
   7. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
   8. Minimum CWP Rating: 175 psig.
   9. Maximum Operating Temperature: 200 deg F.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:
   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. Apollo Flow Controls; Conbraco Industries, Inc.
      b. Armstrong Pumps, Inc.
      c. Bell & Gossett; a Xylem brand.

d. WATTS.
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. WATTS.
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.

2.3 EXPANSION TANKS AND FITTINGS

A. Bladder-Type ASME Expansion Tanks:
1. 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 in accordance with ASME BPVC, Section VIII, Division 1.
2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity. Field-replaceable bladder.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

2.4 STRAINERS

A. Y-Pattern Strainers:
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. Keckley Company.
b. Metraflex Company (The).
c. Titan Flow Control, Inc.
d. WATTS.
2. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
3. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
4. Strainer Screen: Stainless-steel, 40-mesh strainer, or perforated stainless-steel basket.
5. CWP Rating: 125 psig.

2.5 GROOVED END FABRICATED DROPS

A. Pump Vibration Isolation Drops: Factory assembled for pipe sizes 3" through 12". Orange enamel coated assembly, consisting of a Class 150 flange for pump connection
   1. Suction Pump Drop: consisting of a suction diffuser with stainless steel basket, butterfly valve with offset stem for 360-degree circumferential seating, and pipe spool with thermometer and pressure ports. Assembly is installation-ready, with flexible couplings to accommodate vibration attenuation and stress relief. Assembly rated for working pressure to 300-psig. Basis of Design: Victaulic Series 381.
   2. Discharge Pump Drop: Tri-service valve assembly consisting of a spring-actuated Venturi-Check valve and butterfly valve with offset stem for 360-degree circumferential seating, and pipe spool with thermometer and pressure ports. Assembly is installation-ready, with flexible couplings to accommodate vibration attenuation and stress relief. Assembly rated for working pressure to 300-psig. Basis of design: Victaulic Series 380.

B. AHU Vibration Isolation Drop: Manufactured grooved end vibration isolation drop for air handling unit coil supply and return connections in sizes 2" through 6" to accommodate isolation, straining, balancing, and drainage. Orange enamel coated drop, consisting of ASTM A53 carbon steel pipe spool, Victaulic #20 (straight) and #25 (reducing) tees or Style 920/920N Mechanical-T fittings, with base end cap with drain outlet and DZR brass drain valve. Supply connections include a Vic-300 MasterSeal butterfly valve and Style 732 Y-pattern strainer with PT ports, and the return connection includes a Series 787 or 789 circuit balancing valve. Installation-ready, with flexible couplings to accommodate vibration attenuation and stress relief, rated for working pressure to 300-psig. Basis of design: Victaulic Series 385.

2.6 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.

2.7 REDUCED PRESSURE ZONE BACKFLOW PREVENTORS:

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. Watts Regulator
   2. Zurn
   3. Conbraco
   4. Wilkins

B. Bronze body construction. The assembly shall have the following features:
   1. Internal pressure relief valve located between two positive seating check valves with captured stainless steel springs and silicone seat discs.
   2. Replaceable seats and seat discs.
   3. Two resilient-seated isolation valves.

4. Four resilient-seated test cocks and air-gap drain fitting.
5. End Connections: Threaded FNPT.
6. Maximum Working Temperature and Pressure Ratings: 180 Deg F/175 psig.
7. Bronze Y-type strainer.

C. The assembly shall meet the requirements of ASSE Standard 1013 and AWWA Standard C511

PART 3 - EXECUTION

3.1 HYDRONIC SPECIALTIES INSTALLATION

A. Install specialties in accordance with manufacturer's instructions to permit intended performance.

B. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

C. 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.
1. Automatic vents shall be provided in mechanical equipment rooms and in non-accessible locations.
2. Manual vents shall be provided elsewhere.
3. Attach a copper tube blowdown to the nearest drain.

D. Do not install hydronic pressure gages until after systems are pressure tested.

E. Provide combination of valves and fittings or triple duty valve as shown on discharge side of base mounted centrifugal pumps where indicated.

F. Support pump fittings with floor mounted pipe and flange supports.

G. Strainers shall be provided upstream of each pump, control valve, steam trap, pressure reducing valve, and elsewhere as required to protect downstream equipment.

H. Startup strainer screens with a finer screen shall be provided and used during operation of systems during the construction period. New strainer screens shall be provided at completion of commissioning.

I. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

J. Provide drain with valve and hose connection on strainer blow down connection.

K. Clean and flush glycol system before adding glycol solution.

L. Feed glycol solution to system through make-up line with pressure regulator, venting system high points.

M. Perform tests determining strength of propylene glycol and water solution and submit written test results.

3.2 CALIBRATED BALANCE VALVE SELECTION

A. The contractor shall be responsible for selection of the appropriate size of all calibrated balance valves. Select valve size such that optimal accuracy is achieved when balanced to the flow rate as indicated on contract documents. Provide all required increasers and reducers to mate the installed calibrated balance valves to the adjacent piping and equipment.

B. Balance Valve Sizing:

General valve sizes based on flow range below and as recommended by the manufacturer.

GMP Low	GPM Hi	Valve Size
0	2.5	1/2"
2.6	4.5	3/4"
4.6	9.0	1”
9.1	22.0	1-1/4”
22.1	35.0	1-1/2”
35.1	75.0	2”
75.1	120.0	2-1/2”
120.1	200.0	3”
200.1	400.0	4”
400.1	500.0	5”
500.1	800.0	6”
800.1	1500.0	8”
1500.1	2500.0	10”
2500.1	3200.0	12”

3.3 VALVE APPLICATIONS

A. Install shut off-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice balancing valves at each branch connection to return main.

C. Provide calibrated flow type balancing valves on water outlet from terminal heating units as shown on drawings.

D. Provide calibrated flow balancing at floor connections to risers and on equipment.

E. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

F. Install check valves at each pump discharge and elsewhere as required to control flow direction.

G. Balancing or Throttling Valves:
1. Provide balancing valves at all equipment, terminal equipment, main branches, pump discharge, chillers, cooling towers, boilers, heating and cooling coils, heat exchangers, converters, branch runouts and at the base of each riser

2. Balancing valves for terminal equipment shall be combination calibrated balancing/shut-off valves with memory stops. Balancing valves shall have integral differential pressure readout ports across the valve seat

H. Provide balancing valves with integral read out ports and memory stops at all terminal unit and equipment connections and at all sub-mains and branches containing two or more terminal units for system balancing.

I. Place valves above accessible ceilings or in open areas to avoid the need for access panels

J. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and

K. 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.

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

M. Pipe relief valve outlet to nearest floor drain.

N. Relief valves shall be provided:
1. Between isolation valves and any heat exchanger, such as a converter, plate and frame heat exchanger, chiller, cooling coil, heating coil, etc.
2. At every building piping system that can be isolated from the main system.

O. Bronze valves shall comply with ASTM-B61 or B62.

P. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

Q. Provide chain operators with sprockets and guides for all valves installed 8"-0" or higher above the floor in mechanical equipment rooms.

3.4 TERMINAL EQUIPMENT CONNECTIONS - HYDRONIC

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 ball 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 according to Division 23 Section "Meters and Gages for HVAC Piping."

E. Provide calibrated flow type balancing valves on water outlet from terminal heating units, on 3-way valve installations as shown on the drawings and in the pumped return tie-in with the return header as shown on drawings.

3.5 FIELD QUALITY CONTROL - HYDRONIC

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 "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.

3.6 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

B. The following training shall be accomplished after the completion of each phase

1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
2. Provide a total of eight (8) hours of instruction at the site, during start-up.
3. Provide four (4) hours of instruction at the site after start-up
    a. Provide two (2) hours at three (3) months after start-up training
    b. Provide one (1) hour at six (6) months after start-up training.
    c. Provide one (1) hour at nine (9) months after start-up training

END OF SECTION 232116

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Separately coupled, base-mounted, end-suction centrifugal pumps.
      a. Basis of Design Bell & Gossett Series E-1510
   2. Close Coupled, in-line centrifugal pumps.
      a. Basis of Design Bell and Gossett Series e-80

1.2 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.

1.3 REFERENCES

A. HI - Hydraulic Institute.

B. ANSI - American National Standards Institute.

C. OSHA - Occupational Safety & Health Administration.

D. ASHRAE – American Society of Heating, Refrigeration and Air-Conditioning Engineers.

E. NEMA - National Electrical Manufacturers Association.

F. UL - Underwriters Laboratories.

G. ETL - Electrical Testing Laboratories.

H. CSA - Canadian Standards Association.

I. NEC - National Electric Codes.

J. ISO - International Standards Organization.

K. IEC - International Electrotechnical Commission.

L. ASME – American Society of Mechanical Engineers.

1.4 ACTION SUBMITTALS

A. Submit each item in this article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Submit manufacturer's installation instructions under provisions of General Conditions and Division 1.
   1. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts lists.
   2. Under provisions of commissioning documentation, testing of pumps, as well as training of owner's operation and maintenance personnel may be required in cooperation with the commissioning consultant.

C. Product Data including certified performance curves and rated capacities of selected model, weights (shipping, installed, and operating), furnished specialties, and accessories. Indicate pump's operating point on curves.

D. 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.

E. Complete Package information Product Data including:
   1. System summary sheet
   2. Sequence of Operation
   3. Power and control wiring diagram
   4. System profile analysis including pump curves, system curve, and variable speed pump curves
   5. Pump data sheets - Rated capacities of selected models and indication of pump's operating point on curves.
      a. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
      b. Indicate pump's operating point on curves
      c. Shop drawing indicating dimensions, required clearances and location and size of each field connection
   6. Submittals on furnished specialties and accessories
   7. Submittals must be specific to this project. Generic submittals will not be accepted

F. A detailed weighted average pump efficiency-Part Load Efficiency Value (PLEV)
   1. Pump Rating Report shall be submitted for each pump.
   2. Pump PLEV shall be based on the standard load profile developed in AHRI 550/590-1998 also known as IPLV or Integrated Part Load Value.
   3. The pump PLEV Rating shall be expressed with load weighting pump PLEV=1/(0.01/A+0.42/B+0.45/C+0.12/D) where

A= Pump Efficiency at 100%
B= Pump Efficiency at 75%
C= Pump Efficiency at 50%
D= Pump Efficiency at 25%

4. Each Pump Efficiency ratings shown with flow matched to load percentage and Specified Control Head.
5. Actual job specific load profile weighting may be substituted for standard IPLV weighting.

G. Pump and motor must meet minimum Department of Energy requirements and have a PEICL value less than 1

H. Specified Control Head shall be 30% TDH or calculated minimum control head specified within the equipment schedule

I. Hanging and supporting requirements should follow the recommendations in the manufacturer's installation instructions

J. Submittals that are "rejected" as being "non-compliant" will be re-reviewed once with all time for subsequent reviews back charged to the contractor in accordance with the engineer's current prevailing rate schedule. If a rate schedule for additional services is included, as part of the contract with the owner that rate schedule shall be used in lieu of the "current prevailing" rate schedule.

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. 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 QUALITY ASSURANCE

A. All equipment or components of this specification section shall meet or exceed the requirements and quality of the items herein specified, or as denoted on the drawings.

B. Ensure pump operation at specified system fluid temperatures without vapor binding and cavitation, is non-overloading in parallel or individual operation, and operates to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer.

C. Ensure pump pressure ratings are at least equal to system's maximum operating pressure at point where installed but not less than specified.

D. Equipment manufacturer shall be a company specializing in manufacture, assembly, and field performance of provided equipment with a minimum of 20 years experience.

E. Equipment provider shall be responsible for providing certified equipment start-up and, when noted, an in the field certified training session. New pump start-up shall be for the purpose of determining pump alignment, lubrication, voltage, and amperage readings. All proper electrical connections, pump's balance, discharge and suction gauge readings, and adjustment of head, if required. A copy of the start-up report shall be made and sent to both the contractor and to the Engineer.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the site in such a matter as to protect the materials from shipping and handling damage. Provide materials on factory provided shipping skids and lifting lugs if required for handling. Materials damaged by the elements should be packaged in such a matter that they could withstand short-term exposure to the elements during transportation.

B. Store materials in clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage.

C. Use all means necessary to protect equipment before, during, and after installation.

D. All scratched, dented, and otherwise damaged units shall be repaired or replaced as directed by the Architect Engineer.

1.9 WARRANTY:

A. Provide a minimum One (1) year warranty on materials and installation under provision of Section 01 78 36. from system acceptance Per Phase

B. The warrantee period starts after each phase when the owner has beneficial occupancy of the completed phase.

1.10 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. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
   1. Heating Water Piping: 100 psig at 200 deg F.
   2. Cooling Water Piping: 150 psig at 150 deg F.

3. Condenser-Glycol Water Piping: 150 psig at 73 deg F.
4. Glycol solution for all systems: 40 % Propylene Glycol

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 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMP (Series e-1510)

A. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

B. Manufacturers:
1. Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett a xylem brand.
   c. ITT Corporation.
   d. TACO Comfort Solutions, Inc.
2. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Contractor shall furnish and install new end suction long coupled pumps for chilled water and hot water heating systems as indicated on the drawings.
1. Basis of Design Pumps shall be series e-1510 as manufactured by Bell & Gossett.
2. Equivalent units as manufactured by other manufacturers may be submitted
3. Pumps shall meet types, sizes, capacities, and characteristics as scheduled on the Equipment Schedule drawings.
4. Pump substitutions shall be provided with connection sizes equal to those scheduled.
5. Pump connections shall not be downsized.
6. Pump substitutions shall not be provided at efficiencies less than those scheduled.

D. Pump Construction:
1. The pumps shall be long coupled, base mounted, single stage, end suction, vertical split case design, in cast iron stainless steel fitted, specifically designed for quiet operation.
   a. Suitable standard operations at 225°F and 175 PSIG working pressure or optional operations at up to 250°F and 250 PSIG working pressures.
   b. Working pressures shall not be de-rated at temperatures up to 250F.
   c. The pump internals shall be capable of being services without disturbing piping connections, electrical motor connections or pump to motor alignment.
2. The pumps shall be composed of three separable components a motor, bearing assembly, and pump end (wet end).
   a. The motor shaft shall be connected to the pump shaft via a replaceable flexible coupling.
3. 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 threaded companion-flange 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.

4. 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.
5. Pump Shaft: Type 316 stainless steel.
6. A bearing assembly shall support the shaft via two heavy-duty regreaseable ball bearings.
    a. Bearing assembly shall be replaceable without disturbing the system piping and shall have foot support at the coupling end.
    b. Pump bearings shall be regreaseable without removal of the bearings from the bearing assembly.
    c. Thermal expansion of the shaft toward the impeller shall be prevented via an inboard thrust bearing.
7. The bearing assembly shall have a solid SAE1144 steel shaft.
    a. A stainless-steel shaft sleeve shall be employed to completely cover the wetted area under the seal.
8. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and bellows and gasket compatible with 30% Propylene Glycol.
9. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

E. Components
1. Pump shall be equipped with an internally flushed mechanical seal assembly installed in an enlarged tapered seal chamber.
    a. Application of an internally flushed mechanical seal shall be adequate for seal flushing without requiring external flushing lines.
    b. Seal assembly shall have Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.
2. Bearing assembly shaft shall connect to a stainless-steel impeller.
    a. Impeller shall be both hydraulically and dynamically balanced to ANSI/HI 9.6.4-2016, balance grade G6.3 and secured by a stainless-steel locking cap screw or nut.
3. Pump should be designed to allow for true back pull-out allowing access to the pump's working components, without disturbing motor or piping, for ease of maintenance.
4. A center drop-out type coupling, capable of absorbing torsional vibration, shall be employed between the pump and motor.
    a. Pumps for variable speed application shall be provided with a suitable coupling sleeve.
    b. Coupling shall allow for removal of pump's wetted end without disturbing pump volute or movement of the pump's motor and electrical connections.
    c. On variable speed applications the coupling sleeve should be constructed of an neoprene material to maximize performance life.
5. An ANSI and OSHA rated coupling guard shall shield the coupling during operation.
    a. Coupling guard shall be dual rated ANSI B15.1 and OSHA 1910.219 compliant coupling guard and contain viewing windows for inspection of the coupling.
    b. No more than .25 inches of either rotating assembly shall be visible beyond the coupling guard.
6. Pump volute shall be of a cast iron design for heating systems with integrally cast pedestal volute support, rated for 175 PSIG with integral cast iron flanges drilled for 125# ANSI companion flanges.
    a. Volute shall include gauge ports at nozzles, and vent and drain ports.

7. Base plate shall be of structural steel or fabricated steel channel configuration fully enclosed at sides and ends, with securely welded cross members and fully open grouting area (for field grouting).
    a. The minimum base plate stiffness shall conform to ANSI/HI 1.3.8.2.1-2019 for grouted Horizontal Baseplate Design standards.
8. Pump shall be of a maintainable design and, for ease of maintenance, should use machine fit parts and not press fit components.
9. The pump(s) vibration limits shall conform to Hydraulic Institute ANSI/HI 9.6.4-2016 for recommended acceptable unfiltered field vibration limits as measured per ANSI/HI 9.6.4-2016 Figure 9.6.4.2.3.1 for pumps with rolling contact bearings.
10. Pump manufacturer shall be ISO-9001 certified.
11. Each pump shall be hydrostatically tested 1.5 times the maximum rated working pressure and name-plated before shipment.
12. Pump shall conform to ANSI/HI 9.6.3.1-2012 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer.
13. 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, EPDM coupling sleeve for variable-speed applications.
14. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
15. 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.
16. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    a. Motors shall be Permanent Magnet (PM) type shall meet scheduled horsepower, speed, voltage, and enclosure design.
        1) Pump and motors shall be factory aligned and shall be realigned after installation by the manufacturer’s representative.
    b. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications and conform to standards outlined in EISA 2007
    c. Enclosure: Totally enclosed, fan cooled.
    d. NEMA Premium Efficient motors as defined in NEMA MG 1.
    e. 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.
    f. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
    g. Variable-speed motor.
    h. Provide integral pump motor variable-speed controller

F. Accessories
1. Provide one mechanical seal for each model type of primary pump.
2. Provided with internal volute wear rings, galvanized drip pan, or special spacer couplings.
3. EPR/Silicon Carbide-Silicon Carbide seal should be used in lieu of the Buna standard seal 225° F maximum operating temperature.
4. Provide Sediment Separator shall be installed on the flushing line between the pump discharge flange and the seal area.
    a. The sediment separator is installed to increase the overall life expectancy of the seal on inherently dirty systems.

b. The separator shall remove dissolved solids from the flushing medium before the fluid enters the seal area where it can damage and shorten the life of the seal.

G. Capacities and Characteristics:
1. See Schedule on the Drawings.

2.3 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS (e-80 Series)

A. Source Limitations: Obtain pumps from single source from single manufacturer.

B. 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.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, replaceable bronze wear rings, and threaded union-end 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 Stub Shaft: Type 304 stainless steel.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and EPDM rubber bellows and gasket. Include water slinger on shaft between motor and seal.
5. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.

D. Shaft Coupling: Rigid, axially-split spacer coupling to allow service of pump seal without disturbing pump or motor.

E. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
1. NEMA Premium Efficient motors as defined in NEMA MG 1.
2. 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.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
4. Variable-speed motor.

F. Capacities and Characteristics:

1. Refer to scheduled pumps on drawings.

2.4 AUTOMATIC CONDENSATE PUMP UNITS

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. Grundfos Pumps Corporation.

2. Hartell Pumps; Milton Roy.
3. Little Giant Pump Co. (Model VCMA-15UL)

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. Capacities and Characteristics:
1. Tank Capacity: 0.25 Gallon.
2. Pump Capacity: 25 GPH.
3. Maximum Lift: 10 feet.
4. Motor Horsepower: 60 watts.
5. Electrical Characteristics:
a. Volts: 120.
b. Phase: Single.
c. Hertz: 60 Hz.
d. Full-Load Amperes: 1 A.

2.5 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:
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. Armstrong Pumps, Inc.
b. Bell & Gossett; a Xylem brand.
c. TACO Comfort Solutions, Inc.
2. Components
a. Angle pattern.
b. 175-psig pressure rating, cast or ductile-iron body and end cap, pump-inlet fitting.
c. Bronze 16-mesh wire startup and Type 304 stainless steel permanent strainers with 3/16-inch.
d. Type 304 stainless steel straightening vanes.
e. Drain plug.
f. Factory-fabricated support.
g. The suction diffuser body shall be made of either cast iron or ductile iron.
h. The suction diffuser shall include a Flow Cone to eliminate recirculation and direct flow completely out of the body and into the pump suction.
i. The suction diffuser shall include a full-length, 4-plane, removable straightening vane.
j. The straightening vane shall be made of either carbon steel or 304 stainless steel.
k. The suction diffuser shall include a full-length removable orifice cylinder with 3/16” perforations and 51% open area.
l. The orifice cylinder shall be made of either carbon steel or 304 stainless steel.
m. The suction diffuser shall have a full-length removable start-up strainer.
n. The start-up strainer shall be made of 16 mesh bronze wire.

o. The suction diffuser shall be available with either flanged end connections or grooved end connections.
p. Flange end connections should be designed according to ANSI Class 150 Standards.
q. Suction diffuser models with either flange x flange or groove x flange end connections should be rated for 175 psi (1,207 kPa) maximum working pressure. Models with groove x groove end connections should be rated for 300 psi (2,068 kPa) working pressure.
r. The suction diffuser shall have a maximum temperature rating of 250°F (121°C).

3. Accessories
a. Pressure/Temperature port.
b. Adjustable support foot.

B. Triple-Duty Valve:
1. ANGLE PATTERN
a. Pipe sizes 1-1/4" and larger
b. 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) Armstrong Pumps, Inc.
2) Bell & Gossett; a Xylem brand.
3) TACO Comfort Solutions, Inc.
c. Components
1) The valve shall be an angle pattern, non-adjustable design.
2) 175-psig pressure rating, cast or ductile-iron body, pump-discharge fitting.
3) Valve with multi-turn stem and memory stop to allow valve to be returned to its original position after shutoff.
4) Brass valve disc with EPDM rubber seat.
5) Type 304 stainless steel valve stem.
6) Drain plug and bronze-fitted shutoff, balancing, and check valve features.
7) Brass gauge ports with integral check valve and orifice for flow measurement
8) The valve shall be a globe valve design.
9) The valve shall have a spring-loaded check valve design to prevent gravity circulation and backflow.
10) The valve shall have a calibrated nameplate with multi-turn stem.
11) The valve shall include a rubber memory button to allow the valve to be re-balanced to its original position after shut-off or maintenance.
12) The valve shall have a fully backseating disc to allow the valve packing to be replaced while under pressure.
13) The valve body shall be made of either cast iron or ductile iron.
14) The valve disc shall be made of brass with an EPDM rubber seat.
15) The valve stem shall be made of stainless steel.
16) The valve spring shall be made of stainless steel.
17) The valve shall have flanged end connections.
18) Flange end connections should be designed according to ANSI Class 150 Standards.
19) The valve shall be rated for 175 psi 1,207 kPa maximum working pressure.
20) The valve shall have a maximum temperature rating of 250°F 121°C.
d. Accessories
1) Pressure/Temperature port.

2. STRAIGHT PATTERN
   a. Pipe sizes up to 1”
   b. 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) Armstrong Pumps, Inc.
      2) Bell & Gossett; a Xylem brand.
      3) TACO Comfort Solutions, Inc.
   c. Components
      1) The valve shall be a straight pattern, non-adjustable design.
      2) 175-psig pressure rating, cast or ductile-iron body, pump-discharge fitting.
      3) Valve with multi-turn stem and memory stop to allow valve to be returned to its original position after shutoff.
      4) Brass valve disc with EPDM rubber seat.
      5) Type 304 stainless steel valve stem.
      6) Drain plug and bronze-fitted shutoff, balancing, and check valve features.
      7) Brass gauge ports with integral check valve and orifice for flow measurement
      8) The valve shall be a globe valve design.
      9) The valve shall have a spring-loaded check valve design to prevent gravity circulation and backflow.
      10) The valve shall have a calibrated nameplate with multi-turn stem.
      11) The valve shall include a rubber memory button to allow the valve to be re-balanced to its original position after shut-off or maintenance.
      12) The valve shall have a fully backseating disc to allow the valve packing to be replaced while under pressure.
      13) The valve body shall be made of either cast iron or ductile iron.
      14) The valve disc shall be made of brass with an EPDM rubber seat.
      15) The valve stem shall be made of stainless steel.
      16) The valve spring shall be made of stainless steel.
      17) The valve shall be available with either flanged end connections or grooved end connections.
      18) Flange end connections should be designed according to ANSI Class 150 Standards.
      19) Valve models with flange x flange end connections shall be rated for 175 psi maximum working pressure. Models with groove x groove end connections should be rated for 300 psi working pressure.
      20) The valve shall have a maximum temperature rating of 250°.
   d. Accessories
      1) Pressure/Temperature port

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. Where installing piping adjacent to pump, allow space for service and maintenance.

B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

D. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

E. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

F. Install check valve on each condensate pump unit discharge unless unit has a factory-installed check valve.

G. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

H. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain or exterior wall.

I. 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 devices.

J. Equipment Mounting for In-Line Pumps Suspended from Structure: Install in-line pumps with continuous-thread hanger rods and elastomeric hangers of size required to support weight of in-line pumps.
   1. Install in-line pumps with continuous-thread hanger rods spring hangers with vertical-limit stop of size required to support weight of in-line pumps.
   2. For larger inline pumps support pipes and pump off the floor as recommended by the manufacturer.

3.3 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMP (Series e-1510)

A. All components shall be installed in accordance with manufacturer’s installation instructions.

B. Reduction from line size to pump connection size shall be made with eccentric reducers attached to the pump with tops flat to allow continuity of flow.

C. Furnish and install triple duty valves on the discharge side of all pumps and furnish and install a line size shut-off valve on the suction side of all pumps. Anywhere that 5 straight pipe diameters of pipe cannot be provided on the inlet side of a pump a suction diffuser shall be used to provide appropriate flow distribution into the eye of the pump's impeller.

D. Provide temperature and pressure gauges where and as detailed or directed.

E. On systems where pump seals require flushing water or cooling water for a heat exchanger kit, provide cooling water supply piping and connections as well as the return piping, if required. Piping should be of adequate size to pass required flow rate.

F. Proper access space around a device should be left for servicing the component. No less than the minimum recommended by the manufacturer.

G. Provide an adequate number of isolation valves for service and maintenance of the system and its components.

H. Circulating pump shall have sufficient capacity to circulate the scheduled GPM against the scheduled external head (feet) with the horsepower and speed as scheduled and/or as denoted on the drawings. Motors shall be of electrical characteristics as scheduled, denoted and/or as indicated on the electrical plans and specifications. Pump characteristics shall be such that the head of the pump under varying conditions shall not exceed the rated horsepower of the drive motor.

I. On systems where the final balancing procedure requires the triple duty valve to be throttled more than 25% to attain design flow (on a constant speed pumping system), and no future capacity has been built into the pump, the pump impeller must be trimmed to represent actual system head resistance. The pump provider and engineer of record, based on the balancing contractor's reports, shall determine the final impeller trim diameter.

J. Install foot mounted and base mounted pumps on housekeeping pad, via anchor bolts. Set and level and grout in place.

K. All piping shall be brought to equipment and pump connections in such a manner so as to prevent the possibility of any loads or stresses being applied to the connections or piping. All piping shall be fitted to the pumps even though piping adjustments may be required after the pipe is installed.

L. On components that require draining, contractor must provide piping to and discharging into appropriate drains.

M. Provide drains for bases and seals, piped to and discharging into floor drains.

N. Power wiring, as required, shall be the responsibility of the electrical contractor. All wiring shall be performed per manufacturer's instruction and applicable state, federal, and local codes.

O. Control wiring for remote mounted switches and sensor / transmitters shall be the responsibility of the control's contractor. All wiring shall be performed per manufacturer's instructions and applicable state, federal, and local codes.

3.4 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. 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.

C. Comply with pump and coupling manufacturers' written instructions.

D. 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.

3.5 PIPING CONNECTIONS

A. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

B. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

C. Install triple-duty valve on discharge side of pumps.

D. 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.

E. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

F. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

3.6 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.

3.7 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."

3.8 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.

3.9 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.

3.10 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

B. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of eight (8) hours of instruction at the site, during start-up.
   3. Provide four (6) hours of instruction at the site after start-up
      a. Provide two (2) hours at three (3) months after start-up training

b. Provide one (2) hour at six (6) months after start-up training.
c. Provide one (2) hour at nine (9) months after start-up training

END OF SECTION 232123

SECTION 232300 - REFRIGERANT 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. Refrigerant pipes and fittings.
   2. Refrigerant piping valves and specialties.
   3. Refrigerants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and piping specialty.
   1. Include pressure drop, based on manufacturer's test data, for the following:
      a. Thermostatic expansion valves.
      b. Solenoid valves.
      c. Hot-gas bypass valves.
      d. Filter dryers.
      e. Strainers.
      f. Pressure-regulating valves.
   2. Product Data for EA Prerequisite "Fundamental Refrigerant Management": For refrigerants, indicating compliance with refrigerant management practices.

B. Shop Drawings:
   1. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
   2. Show interface and spatial relationships between piping and equipment.
   3. Shop Drawing Scale: 1/4-inch equals 1 foot.
   4. Welding certificates.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:
   1. Suction Lines for Air-Conditioning Applications: 300 psig.
   2. Suction Lines for Heat-Pump Applications: 535 psig.
   3. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR.
   1. All refrigerant piping shall be Type ACR copper tubing.
   2. All refrigerant piping joints and fittings shall be brazed.
   3. Refrigerant pipe fittings shall be wrought copper.
   4. A nitrogen purge shall be used during all brazing processes.
   5. Twinning fittings shall be “Y” configuration by heat pump manufacturer to combine 2 circuit compressor and 2 circuit coil to a single refrigerant gas and liquid pair between them.

B. Brazing Filler Metals: AWS A5.8/A5.8M.

C. Flexible Connectors:
   1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
   4. Working Pressure Rating: Factory test at minimum 500 psig.
   5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

A. Valves and Specialties are normally provided with the chiller and are factory installed by the manufacturer. Provide any Valves and Specialties listed below required by the manufacturer if not provided by the chiller manufacturer.

B. Diaphragm Packless Valves:
   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. Danfoss Inc.
      b. Parker Hannifin Corp.
      c. Paul Mueller Company.
   2. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
   3. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
   4. Operator: Rising stem and hand wheel.
   5. Seat: Nylon.
   6. End Connections: Socket, union, or flanged.
   7. Working Pressure Rating: 500 psig.
   8. Maximum Operating Temperature: 275 deg F.

C. Packed-Angle Valves:
   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. Danfoss Inc.
      b. Heldon Products; Henry Technologies.
      c. Parker Hannifin Corp.
   2. Body and Bonnet: Forged brass or cast bronze.
   3. Packing: Molded stem, back seating, and replaceable under pressure.
   4. Operator: Rising stem.
   5. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
   6. Seal Cap: Forged-brass or valox hex cap.
   7. End Connections: Socket, union, threaded, or flanged.
   8. Working Pressure Rating: 500 psig.
   9. Maximum Operating Temperature: 275 deg F.

D. Check Valves:
   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. Apollo Flow Controls; Conbraco Industries, Inc.
      b. Danfoss Inc.
      c. Emerson Climate Technologies.
   2. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
   3. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
   4. Piston: Removable polytetrafluoroethylene seat.
   5. Closing Spring: Stainless steel.
   6. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
   7. End Connections: Socket, union, threaded, or flanged.

8. Maximum Opening Pressure: 0.50 psig.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 275 deg F.

E. Service Valves:
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. Danfoss Inc.
   b. Heldon Products; Henry Technologies.
   c. Parker Hannifin Corp.
2. Body: Forged brass with brass cap including key end to remove core.
3. Core: Removable ball-type check valve with stainless-steel spring.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Copper spring.
6. Working Pressure Rating: 500 psig.

F. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).
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. Danfoss Inc.
   b. Emerson Climate Technologies.
   c. Parker Hannifin Corp.
2. Body and Bonnet: Plated steel.
3. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Threaded.
6. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
7. Working Pressure Rating: 400 psig.
8. Maximum Operating Temperature: 240 deg F.

G. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
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. Danfoss Inc.
   b. Heldon Products; Henry Technologies.
   c. Parker Hannifin Corp.
2. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
3. Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Threaded.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.

H. Thermostatic Expansion Valves: Comply with AHRI 750.

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. Danfoss Inc.
   b. Emerson Climate Technologies.
   c. Heldon Products; Henry Technologies.
   d. Mitsubishi LEV kit
2. Body, Bonnet, and Seal Cap: Forged brass or steel.
3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Packing and Gaskets: Non-asbestos.
5. Capillary and Bulb: Copper tubing filled with refrigerant charge.
6. Suction Temperature: 40 deg F.
7. Superheat: Adjustable.
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 450 psig.
10. LEV control box and valve shall interface with the heat pump outdoor controller and the AUH controls to operate the 'TX' Valve

I. Straight-Type Strainers:
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. Danfoss Inc.
   b. Heldon Products; Henry Technologies.
   c. Parker Hannifin Corp.
2. Body: Welded steel with corrosion-resistant coating.
3. Screen: 100-mesh stainless steel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

J. Angle-Type Strainers:
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. Danfoss Inc.
   b. Heldon Products; Henry Technologies.
   c. Parker Hannifin Corp.
2. Body: Forged brass or cast bronze.
3. Drain Plug: Brass hex plug.
4. Screen: 100-mesh monel.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

2.4 REFRIGERANTS

A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

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. Arkema Inc.
   b. DuPont Fluorochemicals Div.
   c. Genetron Refrigerants; Honeywell International Inc.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
   1. Copper, Type ACR , annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
   2. Copper, Type ACR , annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping:
   1. Copper, Type ACR , annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
   2. Copper, Type ACR , annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

D. Safety-Relief-Valve Discharge Piping, Multiple Tube Sizes and Joining Materials:
   1. NPS 5/8 and Smaller: Copper, Type ACR , annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless or packed-angle valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless or packed-angle valves on inlet and outlet side of filter dryers.

E. Install a full-size, three-valve bypass around filter dryers.

F. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.

3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

G. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

H. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

I. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
1. Solenoid valves.
2. Thermostatic expansion valves.
3. Compressor.

J. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

K. Install flexible connectors at compressors and remote evaporators.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements 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.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 230900 "Instrument Controls for HVAC"

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:
1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

S. 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."

T. 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."

U. 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 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. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

B. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 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. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing, 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.

D. Support horizontal piping within 12 inches of each fitting.

E. Support vertical runs of copper tubing to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Refrigerant piping shall be insulated. Refer to specification section 230719

3.6 FIELD QUALITY CONTROL

A. Refer to 230500 section 3.10 TESTING for additional New York State testing requirements

B. Perform the following tests and inspections:
1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

C. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:
   1. Install core in filter dryers after leak test but before evacuation.
   2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
   4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
   1. Open shutoff valves in condenser water circuit.
   2. Verify that compressor oil level is correct.
   3. Open compressor suction and discharge valves.
   4. Open refrigerant valves except bypass valves that are used for other purposes.
   5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 232513 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC 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 the following water treatment for closed-loop hydronic systems:
   1. Chemicals. (Addition to the existing system)

1.3 DEFINITIONS

A. RO: Reverse osmosis.

B. TDS: Total dissolved solids consist of salts and other materials that combine with water as a solution.

C. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
   1. Chemical material safety data sheets.
   2. Inhibited propylene glycol.
   3. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
   4. Field quality-control reports.
   5. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
   6. Water Analysis: Illustrate water quality available at Project site.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, 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.

PART 2 - PRODUCTS

2.1 HVAC WATER-TREATMENT MANUFACTURERS

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. Aqua-Chem, Inc.
2. Earthwise Environmental Inc.
3. Suez Water Technologies (Formerly GE Water)

2.2 PERFORMANCE REQUIREMENTS

A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems, as indicated in this Specification. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

2.3 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer, compatible with piping system components and connected equipment, and able to attain water quality specified in "Performance Requirements" Article.

2.4 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:
1. pH: 9.0 to 10.5.
2. "P" Alkalinity: 100 to 500 ppm.
3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: Maximum of 100 ppm. Revise this value if closed system contains glycol.
5. Corrosion Inhibitor: One of the following based on fluid quality test
    a. Sodium Nitrate: 1000 to 1500 ppm.
    b. Molybdate: 200 to 300 ppm.
    c. Chromate: 200 to 300 ppm.

d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
e. Chromate Plus Molybdate: 50 to 100 ppm each.

6. Soluble Copper: Maximum of 0.20 ppm.
7. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of 10 ppm.
8. Total Suspended Solids: Maximum of 10 ppm.
9. Ammonia: Maximum of 20 ppm.
10. Free Caustic Alkalinity: Maximum of 20 ppm.
11. Microbiological Limits:
    a. Total Aerobic Plate Count: Maximum of 1000 organisms/mL.
    b. Total Anaerobic Plate Count: Maximum of 100 organisms/mL.
    c. Nitrate Reducers: 100 organisms/mL.
    d. Sulfate Reducers: Maximum of zero organisms/mL.
    e. Iron Bacteria: Maximum of zero organisms/mL.

B. Closed hydronic systems, including glycol system, shall have the following water qualities:
1. Water Test Results:
    a. pH: maintain a value from 8 to 10.3.
    b. Conductivity: Less than 3,000mmhos
        1) System must be capable of operating for a minimum of (4) weeks on a 10 micron filter bag.
    c. Nitrite (steel protection): maintain a level of 300 to 600 PPM (1000 PPM if system is off-line).
    d. Azole (copper protection): 3-6 PPM Total (greater than 3 PPM free and available). 6 PPM if system is offline.
    e. Iron: Less than 0.5 PPM
    f. Copper: Less than 0.2 PPM
    g. Bacteriological testing (i.e. bioscan, dipslide): Less than or equal to 1,000 Cells/ml. A bioscan of ATP at 50 RLU or lower.
    h. Mild steel corrosion coupons: Less than 0.5 mils per year (MPY) corrosion rate. (1 mil = 0.001")
    i. Copper corrosion coupons: Less than 0.1 mils per year (MPY) corrosion rate.
    j. Glycol percentage and type must be listed on test results

C. Install bypass chemical feeders in each hydronic system where indicated.
1. Install in upright position with top of funnel not more than 48 inches above the floor.
2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.

D. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

E. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

F. Fill systems that have antifreeze or glycol solutions with the following concentrations:
1. Hot-Water Heating Piping: Water.
2. Chilled-Water Piping: Water.
3. Condenser Cooling-Water Piping: Minimum of 40 percent propylene glycol.

2.5 INHIBITED PROPYLENE GLYCOL

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. Dow Chemical Company (The).
   2. Dynalene.
   3. Fremont Industries.

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 8-10.
   4. Concentrated inhibited propylene glycol is to be 95.5 percent propylene glycol by weight and 4.5 percent performance additives.
   5. 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.
   6. Provide only propylene glycol that is specifically blended for HVAC application. Automotive-type antifreeze is unacceptable.
   7. Concentration shall be a minimum of 30%

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. Systems shall be filled with propylene glycol to achieve a minimum of 30% conservation. By mixing with Reverse osmosis water (RO)

B. System feed locations shall be in the service building #180 where the boilers and chillers are located.

C. Provide fluid for entire system to include Building #39, Service Building and exterior piping network Approximate system volumes are as noted below
   1. Add additional glycol to the existing system for the final fill for both the chilled water and heating water system new piping for area 5.

D. Building loops
   1. Refer to Drawings for the hydronic schematics for the building

2. Systems shall be filled with propylene glycol to achieve a minimum of 30% concentration by mixing with Reverse osmosis water (RO)
3. Fill/make-up equipment
   a. Chemical solution tanks.
   b. Chemical solution injection pumps.
   c. Water meter in makeup supply to system.
   d. Pressure switch to operate injection pump as necessary to maintain glycol system pressure.

3.3 PIPING CONNECTIONS

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

B. Where installing piping adjacent to equipment, allow space for 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 230523.12 "Ball Valves for HVAC Piping."

E. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

3.4 ELECTRICAL CONNECTIONS

A. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 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. Tests and Inspections:
   1. Inspect field-assembled components and equipment installation, including piping and electrical connections.

2. 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.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. 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.
6. 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.
7. Cap and subject piping to static water pressure of 50 psig 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.
8. Repair leaks and defects with new materials, and retest piping until no leaks exist.

E. Equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. At four-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 "Performance Requirements" Article.

H. Comply with ASTM D3370 and with the following standards:
1. Silica: ASTM D859.
2. Acidity and Alkalinity: ASTM D1067.
3. Iron: ASTM D1068.
4. Water Hardness: ASTM D1126.

3.6 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion and scale formation for hydronic 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.

3.7 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

B. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of four (4) hours of instruction at the site, during start-up.
   3. Provide four (4) hours of instruction at the site after start-up
      a. Provide two (2) hours at three (3) months after start-up training
      b. Provide one (1) hour at six (6) months after start-up training.
      c. Provide one (1) hour at nine (9) months after start-up training

END OF SECTION 232513

SECTION 232533 - HVAC WATER FILTRATION 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 specifies cleaning and treatment of circulating HVAC water systems, including the following:
   1. Closed Loop Cooling Systems
   2. Closed Loop Heating Systems
   3. Closed Loop Condenser System

B. Related Requirements:
   1. Section 232513 "Water Treatment for Closed-Loop Hydronic Systems" for hydronic water-treatment equipment.

1.3 DEFINITIONS

A. RO: Reverse osmosis.

B. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.4 REFERENCES

A. ASHRAE 2015 HVAC APPLICATIONS
   1. Chapter 49 Section 49.1, 49.2, 49.4, 49.9, 49.18

1.5 PERFORMANCE REQUIREMENTS

A. 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.

B. HVAC water treatment to be based upon the quality of water available at Project Site, HVAC system equipment requirements and recommendations, operating personnel capabilities and the requirements and guidelines of all authorities having jurisdiction.

C. Closed hydronic systems, including hot water heating shall have the following water qualities:
   1. pH: Maintain a value within 6.6 – 8.5
   2. “p” Alkalinity: 300ppm > Main Water Supply

3. Chloride: Less than 100ppm
4. Total Hardness: 50 – 200ppm
5. Copper: Less than 3ppm
6. TDS: Maintain a value within 10% of main water supply
7. Iron: Total Less than 15ppm
8. Aluminum: Less than 1ppm

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product indicated

B. Shop Drawings: Pre-treatment and chemical treatment equipment showing X-POT in-line magnet, isolation valves and dosing port as well as maintenance space required and piping connections to the HVAC systems.

C. Raw Water Analysis: Submit a copy of the Project Site water analysis at the beginning of the project to document the water quality available. Raw water test analysis shall include, at a minimum, the following compositions of water:
1. Calcium Hardness (as ppm CaCO3)
2. Total Hardness (as ppm CaCO3)
3. Total Alkalinity or m-Alkalinity (as ppm CaCO3)
4. pH
5. Silica (as ppm SiO2)
6. Specific Conductivity (□S/cm)
7. Chloride (as ppm Cl-)

D. Treated Water Report: Submit a copy of the Closed Loop System water analysis at the completion of project start-up to document conformance to required conditions.

E. Shop Drawings: Softeners and filtration equipment, maintenance space required, and piping connections to HVAC systems.
1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.7 INFORMATIONAL SUBMITTALS

A. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

B. Field quality-control reports.

C. Water Analysis: Illustrate water quality available at Project site.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For Side Stream Filtration and controllers to include in operation, and maintenance manuals.

1.9 DESCRIPTION

A. The side stream filtration assists Hydronic Heating and Cooling Systems to remain reliable and run at their intended design capabilities, by keeping the Thermal Fluid within the system filtered, clean and free from suspended particulates. This also allows Chemical Inhibitor's and Biocides to remain effective thus reducing the accumulation of Corrosion, Scale and Bio-film deposits which would otherwise cause flow loss, degradation of plant and pipeline material, as well as reduced system reliability, increased operational costs and reactive maintenance costs, water losses and reduced lifespan of system components.

B. This is achieved by a combination of functions by providing an all-in one:
   1. Magnetic Filter
   2. Cartridge Filter (down to 0.5 micron)
   3. Shot Feeder (For adding Water Treatment Chemicals)

PART 2 - PRODUCTS

2.1 SIDE STREAM WATER FILTRATION AND TREATMENT DEVICE

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. Skidmore
   2. Bell & Gossett.

B. The Contractor shall furnish and install a full slipstream filtration device that incorporates a shot feeder, magnetic filter and cartridge filter all in one device as shown and detailed on the contract documents.
   1. The basis of design product shall be the Skidmore® X-POT COMPACT® manufactured by Skidmore of Benton Harbor, MI or an approved substitution.
      a. Model X-POT XP
      b. Model X-POT 6

C. Product Description
   1. The product shall be all stainless-steel construction including all valves and fittings.
   2. Maximum working pressure shall be 150psi with flow rates up to 6.3 Gal/min with a temperature range of 32 to 200F.
   3. Dosing capacity shall be a minimum of 1.18 Gallons and Cartridge Filtration range to be no less than 100 to 0.5µ.
   4. Magnetic filtration shall consist of no less than four (4) rare earth magnets designed for easy removal and cleaning.
   5. Unit to include an automatic air vent.
   6. Total system volume capacity shall be no more than 9,130 Gallons.
   7. The product must be provided with ½" isolation and drain valves and an insulation jacket.
   8. The product must be provided with self-supporting wall-mounting brackets.

D. Spare Parts
   1. The product shall be furnished with a quantity of one (1), 100µ, start-up filter.

2.2 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit:
   1. Manufacturer recommended equipment and chemicals for testing pH, inhibitor, chloride, alkalinity, iron, copper and hardness.
   2. TDS meter required for TDS measurement.

2.3 WATER TREATMENT CHEMICALS

A. X-P035 Sanitizer and Cleaner
   1. Lifts and mobilizes contaminants and bio-film.
   2. Cleans and passivates bare metal surfaces

B. X-P010 Inhibitor
   1. Inhibits development of corrosion, scale and debris/fouling
   2. Environmentally friendly, Neutral pH formula

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 EXAMINATION

A. Verify field conditions and suitability for installation according to manufacturer’s published installation data

3.3 INSTALLATION

A. Equipment Mounting:
   1. Install equipment on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

B. Install equipment per manufacturer’s recommendations and published O&M Manual.

C. Install 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.

3.4 PIPING CONNECTIONS

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

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Make piping connections between HVAC equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232113 "Hydronic Piping."

D. Install shutoff valves on HVAC equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.12 "Ball Valves for HVAC Piping,"

E. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

3.5 ELECTRICAL CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

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. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. 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.
   3. Place HVAC system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
   4. Do not enclose, cover, or put piping into operation until it is tested, and satisfactory test results are achieved.
   5. 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.
   6. 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.
   7. Cap and subject piping to static water pressure of 50 psig 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.
   8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 CHEMICAL DOSING

A. Install water treatment chemicals per manufacturer’s published O&M Manual

3.8 EQUIPMENT MAINTENANCE

A. To ensure optimal equipment performance and system protection, clean magnet grates, check filters and test water chemistry quarterly. Replace filters and add inhibitor as required.

3.9 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 equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:
   1. Periodic field service and consultation.
   2. Customer report charts and log sheets.
   3. Laboratory technical analysis.
   4. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.10 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

C. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of four (4) hours of instruction at the site, during start-up.
   3. Provide four (4) hours of instruction at the site after start-up
      a. Provide two (2) hours at three (3) months after start-up training
      b. Provide one (1) hour at six (6) months after start-up training.
      c. Provide one (1) hour at nine (9) months after start-up training

END OF SECTION 232533

SECTION 233113 - 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. Sheet metal materials.
   4. Duct liner.
   5. Sealants and gaskets.
   6. Hangers and supports.
   7. Outdoor Ductwork
      a. Basis of design Thermaduct, ducts and fittings by Thermaduct, LLC

B. Related Sections:
   1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
   2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 SYSTEM CRITERIA

A. Supply air systems and Return air systems shall be fully ducted.

B. Duct sizing considerations. In general, the maximum permitted duct velocities and pressure losses shall be as follows:
   1. Low pressure supply/return/exhaust mains: 1,500 fpm or 0.10” WC/100’.
   2. Supply mains upstream of VAV terminal units: 2,000 fpm or .15” WC/100’.
   3. Branch ductwork: 1,200 fpm or .10” WC/100’.
   4. Air device run out (supply diffuser, exhaust/return register or grille): 1,000 FPM or .10” WC/100’.
   5. Duct velocities and pressure losses shall be coordinated and adjusted accordingly to meet project specific acoustical requirements.

C. In general, aspect ratios shall not exceed 4 to 1.

D. Ductwork Pressure Class: All ductwork shall be constructed in accordance with the most recent edition of the SMACNA “HVAC Duct Construction Standards, Metal and Flexible” for the external static pressure of the system fan, but not less than 1’ WC static pressure.

E. Ductwork configuration, shapes and sizes can be adjusted as the shop drawings are developed for coordination. Adjustments shall develop complying to the constraints as identified in this section.
   1. Duct shapes (Rectangular, Round, Oval) may be altered as the shop drawings are develop provided velocity and air pressure drops are maintained or lowered.

F. Ductwork Construction
   1. Supply air return air and non-corrosive exhaust ductwork shall be constructed of G-90 galvanized steel.
   2. Shower, bathroom, Janitor closets, and other moist area environments exhaust ductwork shall be constructed of aluminum up to the connection to the main exhaust duct or duct riser, but not less than 10 feet from the air device.
   3. Dryer exhaust ductwork shall be constructed entirely of aluminum or stainless steel and shall comply with all requirements of the 2020 New York State Mechanical and Building Code (with Supplement). Fasteners that project into the airstream are prohibited. Install dryer exhaust with band clamped joints or welded joints. Either application is acceptable, as long as the interior surface is smooth so not to retain lint in the ductwork
   4. All duct accessories including dampers (including fire, smoke, and fire/smoke dampers), turning vanes, splitters, etc. shall be constructed of the same material as the associated duct system.
   5. Round and flat oval ductwork may be used where space conditions warrant.
   6. Spiral seams shall be used where the ductwork is exposed to view and prefabricated fittings shall be used for all duct connections.
   7. Ductwork exposed to view shall be painted in a color selected by the Architect.

G. Miscellaneous
   1. All ductwork to be protected from damage during construction and to be capped and sealed to prevent dust, dirt, water, and debris from entering the duct.
   2. Where the HVAC system is used to provide temporary heating/cooling/ventilation, temporary filters shall be provided with periodic replacement. The temporary filters shall be replaced with new filters prior to the start of commissioning.
   3. Where the HVAC system is used for temporary heating/cooling/ventilation, the ductwork interior shall be cleaned, prior to occupancy, in accordance with the NADCA ACR Standard.

H. Duct Lining
   1. The use of internal duct lining shall be limited to applications where sound attenuation is required or to address a specific acoustical issue/concern

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
   1. Liners and adhesives.
   2. Sealants and gaskets.
   3. Product data: For each type of product indicated

B. Shop Drawings:
   1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work. including.
      a. Factory- and shop-fabricated ducts and fittings.

b. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
c. Elevation of top and bottom of ducts.
d. Dimensions of all duct runs from building grid lines.
e. Fittings.
f. Reinforcement and spacing.
g. Seam and joint construction.
h. Penetrations through fire-rated and other partitions.
i. Equipment installation based on equipment being used on Project.
j. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
k. Hangers and supports, including methods for duct and building attachment and vibration isolation.

2. Coordination Drawings: Plans, drawn to scale, showing coordination general construction, building components, and other building services
3. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
4. Welding certificates.
5. Field quality-control reports.

C. Testing Report: Report to show testing compliance with grease duct testing NYS MC 506.3.2.5

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with 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 D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Installer Qualifications:
1. Outdoor Duct: Manufacturers duct systems to be installed by competent trained field mechanics who demonstrate competence in the HVAC industry.

1.6 OUTDOOR DUCTWORK ADDITIONAL COMPLIANCE

A. SMACNA leakage, Class 1 or less.

B. Manufacturers outdoor duct systems to incorporate a Kingspan KoolDuct fortified inner liner compliant to UL (C-UL) 181 Standard for Safety Listed, Class 1 system, with included testing and passing the following:
1. Test for Surface Burning Characteristics
2. Flame Penetration Test
3. Burning Test
4. Mold Growth and Humidity Test
5. Low Temperature Test and High Temperature Test
6. Puncture Test
7. Static Load Test
8. Impact Test
9. Pressure Test and Collapse (negative pressure) Test

10. High Temperature and Humidity for 90 days
11. Cone Calorimeter
12. ASTM E2257 Standard Test Method for Room Fire Test of Wall and Ceiling Materials and Assemblies
13. ASTM E 84 tested, Tunnel Test, Does not exceed 25 flame spread, 50 smoke developed.
14. DW144, Class B
15. NRTL product approval, (Subpart S of 29 CFR Part 1910, OSHA)
16. ASTM C 423 noise reduction
17. ASTM E 96/E 96M Procedure A for permeability
18. ASTM C 1071 for erosion
19. ASTM C 518: 2004, Standard Test Method for Steady–State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
20. UL 723, Test for Surface Burning Characteristics of Building Materials
21. NFPA Compliance:
    a. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems"
    b. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems"
    c. NFPA 255, “Standard Method of Test of Surface Burning Characteristics of Building Materials

C. Manufacturers outdoor duct systems outer shell shall be a UV stable, 39 mil high impact resistant titanium infused vinyl with included testing as following.
1. UL-94 Flammability V-0
2. ASTM D-638 Tensile Strength of 6250 psi
3. ASTM D-790 Flexible Strength of 11,000 psi
4. ASTM D-4226 Drop Impact Resistance
5. ASTM D-4216 Cell Classification

1.7 PRODUCT DELIVERY AND STORAGE

A. Prevent objectionable aesthetic damage to the outer surface of duct segments during transport and storage.

B. Store duct segments under cover and protect from excessive moisture prior to

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

D. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 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.
   1. Construct ducts of galvanized sheet steel unless otherwise indicated.
   2. For ducts exposed to weather, construct of Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.

B. Transverse Joints: Fabricate joints in accordance with 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."
   1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
   2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
   3. Where specified for specific applications, all joints shall be welded.

C. Longitudinal Seams: Select seam types and fabricate in accordance with 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. “All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.
   1. Where specified for specific applications, all joints shall be welded.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 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."

2.3 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
   1. Construct ducts of galvanized sheet steel unless otherwise indicated.
   2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.
   3. 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. Ductmate Industries, Inc.

b. McGill AirFlow LLC.
c. Sheet Metal Connectors, Inc.
d. Spiral Manufacturing Co., Inc.

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 in accordance with 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."
1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate in accordance with 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."
1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate in accordance with 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."

2.4 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 A653/A653M.
1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

D. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

E. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested in accordance with ASTM D3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: Black.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

F. Reinforcement Shapes and Plates: ASTM A36/A36M, 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.

H. Band Clamps: Provide band clamp connections equivalent to Ductmate Quick-Sleeve for all dryer exhaust ductwork.

2.5 FLEXIBLE DUCTWORK:

A. Flexible ductwork shall only be used for connections to air devices (diffusers, registers, and grilles). Secured with a two metal bands, one for the inner duct and one for the outer insulation/jacket. Tape or plastic bands are not permitted.

B. Flexible ductwork shall not exceed 4 feet in length and shall be properly supported in accordance with the SMACNA HVAC Duct Construction Standards-Metal and Flexible and the duct manufacturer’s installation requirements.

C. Flexible Duct shall consist of an aluminum duct constructed without the use of adhesive. The duct shall have circumferential corrugations for strengthening and flexibility.

D. The flexible ductwork shall be insulated with fiberglass insulation with a reinforced metalized vapor barrier. Provide closures/seals at joints and terminations

E. The flexible ductwork shall have a minimum pressure class rating of 10” WC and shall be UL181 Class 1 Air Duct.

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 in accordance with 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: 4 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 (both PVC coated and bare), stainless steel, or aluminum.
   10. Sealant shall have a VOC content of 420 g/L or less.
   11. Sealant shall comply 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."

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 (both PVC coated and bare), 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. Sealant shall have a VOC content of 420 g/L or less.
   9. Sealant shall comply 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."
   10. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
   11. Service: Indoor or outdoor.
   12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C920.
   1. General: Single-component, acid-curing, silicone, elastomeric.

2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply 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."

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 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. The requirement for seismic restraint shall be determined in accordance with the 2020 New York State Uniform Fire Prevention and Building Code (with Supplement). Ductwork shall be supported in accordance with the latest edition of the SMANCA HVAC Duct Construction Standards-Metal and Flexible.

B. Strap and rod sizes shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible

C. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

D. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

E. 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."

F. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

G. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.

H. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

I. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

J. 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 OUTDOOR RECTANGULAR DUCT AND FITTINGS

A. Product:
   1. Basis of design manufacturer: Thermaduct.

B. The panel shall be manufactured of CFC-free Kooltherm closed cell rigid thermoset resin thermally bonded on both sides to a factory applied .001" (25 micron) aluminum foil facing reinforced with a fiberglass scrim. An added UV stable, 39 mil high impact resistant titanium infused vinyl is factory bonded to the outer surfaces to provide a zero permeability watertight barrier.

C. The thermal conductivity shall be no greater than 0.13BTU • in/Hr •ft2•°F (.018W/m•°C), the thermal conductivity shall be no greater than 0.13BTU • in/Hr •ft2•°F (.018W/m•°C)

D. The density of the Kooltherm foam shall not be less than 3.5 pcf (56 Kg/m3) with a minimum compressive strength of 28 psi (.2 MPa).

E. The panel shall be double wall construction with R-20.1.
   1. Maximum Temperature: Continuous rating of 185 degrees F (70 deg C) inside ducts or ambient temperature surrounding ducts.
   2. Maximum Thermal Conductivity: 0.13 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
   3. Permeability: 0.00 perms maximum when tested according to ASTM E 96/E 96M, Procedure A.
   4. Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   5. Noise-Reduction Coefficient: 0.05 minimum when tested according to ASTM C 423, Mounting A.
   6. Required Markings: All interior duct liner shall bear UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for internal closure materials.
   7. All insulation materials shall be closed cell with a closed cell content of >90%.
   8. R-value:
      a. Double wall 3.0 inch (76 mm) Thick Panel: 20.1 R

F. Closure Materials:
   1. V-Groove Adhesive: Silicone (interior).
   2. UV stable 38 mil high impact resistant titanium infused vinyl (exterior).
      a. Factory manufactured seamless corners.
      b. Cohesive bonded over-lap at corner seam covers.
      c. Water resistant titanium infused welded vinyl seams.
      d. Mold and mildew resistant.
   3. Polymeric Sealing System:
      a. Structural Membrane: Aluminum scrim with woven glass fiber with UV stable vinyl clad applied
      b. Minimum Seam Cover Width: 2 7/8” inches (75 mm)
      c. Sealant: Low VOC.

d. Color: White (colors, matched by architect optional).
e. Water resistant.
f. Mold and mildew resistant.

4. Duct Connectors.
   a. Factory manufactured cohesive bonded strips (low pressure only).
   b. Factory manufactured all aluminum grip flange.
      1) Grip flange
      2) F-flange
      3) H-flange
      4) U-flange
   c. Factory manufactured galvanized 4-bolt flange.

G. Outdoor Cladding
1. Thermaduct outdoor Installations: Duct segments shall incorporate UV stable 39 mil high impact resistant titanium infused vinyl which is introduced during the manufacturing process.

H. Flange coverings
1. Flanges are field sealed airtight before flange covers are installed. Flange covering consists of the following:
   a. Foam tape insulation with molded 39 mil covers.
   b. Air gap (heating only application) with molded 39 mil covers.

I. Weight
1. Thermaduct shall provide low weight stresses on the building framing and support members. The R-8.1 Thermaduct shall have a maximum weight of 3 lbs. per square foot. Hangers and tie-downs are to be detailed on the manufacturer's installing contractors detail drawings prior to installation but not exceeding 13' for duct girth <84" and 8' for duct girth >85" between hangers and designed to carry the weight and wind load of the ductwork.

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 in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. 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.

J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.
   1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
   2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

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 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 OUTDOOR RECTANGULAR DUCT AND FITTINGS SUPPLEMENTAL

A. Shop Fabrication
   1. Certification:
      a. Ducts shall be detailed and fully factory manufactured by Thermaduct, LLC facility system guidelines. All fabrication labor will be certified “yellow label” building trade professionals, compliant to SMWIA and SMACNA labor guidelines (work preservation observed).
   2. Fabrication:
      a. Fabricated joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according to manufacturer’s written and detailed instructions.
      b. Fabricated 90-degree mitered elbows to include turning vanes.
      c. Fabricated duct segments in accordance with manufacturer’s written details.
      d. Duct Fittings shall include 6 inches of connecting material, as measured, from last bend line to the end of the duct. Connections on machine manufactured duct may be 4 inches.
      e. Fabricated duct segments utilizing v-groove method of fabrication. Factory welded or cohesively bonded seams will apply to fully manufactured ductwork and fittings. Internal seams will be supplied with an unbroken layer of low VOC silicone or bonding (for paint shop applications). Each duct segment will be factory supplied with either aluminum grip pro-file or pre-insulated duct connectors in accordance with manufacturer’s detailed submittal guide. Applied duct reinforcement to protect against side deformation from both positive and negative pressure per manufacturer’s design guide based on specified ductwork size and system pressure.
      f. Designed and fabricated duct segments and fittings will be in accordance with “SMACNA HVAC Duct Construction Standards” latest edition.
      g. Both positive and negative ductwork and fittings shall be constructed to incorporate a UL Listed as a Class 1 air duct to Standard for Safety UL 181 liner with an exterior clad for permanent protection against water intrusion.

B. Duct Installation
   1. Duct segments shall be installed be competent HVAC installers.
   2. Install ducts and fittings to comply with manufacturer’s installation instructions as follows:
      a. Install ducts with fewest possible joints.
      b. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
      c. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
      d. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."
      e. Use prescribed duct support spacing as described in this specification and manufacturer’s recommendations.

3. Air Leakage: Duct air leakage rates to be in compliance with “SMACNA HVAC Duct Construction Standards” latest version per applicable leakage class based on pressure.

C. Hanger and Support Installation
1. Contractor to ensure that the ductwork system is properly and adequately supported.
   a. Ensure that the chosen method is compatible with the specific ductwork system requirements per Thermaduct installation detail drawings. Pre-installation should be provided prior to work commencement by installing contractor for approval. .
   b. 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.
2. Supports on straight runs of ductwork shall be positioned at centers not exceeding 13 feet (3.96 m) for duct sections when fabricated in 13 foot (3.96 m) lengths with duct girth less than 84”. Larger duct sizes and short segments with duct girth greater than 84” are to be supported at 8 foot centers or less, in accordance with the Thermaduct installation details provided prior to work commencement.
3. Ductwork shall be supported at changes of direction, at branch duct connections, tee fittings, parallel under turning vanes and all duct accessories such as dampers, etc.
4. The load of such accessories to the ductwork shall be neutralized by the accessory support.

D. Field Quality Control
1. Inspection: Arrange for manufacturer's representative to inspect completed installation and provide written report that installation complies with manufacturer's written instructions.
   a. Remove and replace duct system where inspection indicates that it does not comply with specified requirements.
2. Perform additional testing and inspecting, at the Contractor's expense, to determine compliance of replaced or additional work with specified requirements.

E. Duct Schedule
1. Outdoor Ducts and Fittings:
   a. Thermaduct Rectangular Ducts and Fittings:
      1) Minimum Panel Thickness: Double wall 3” (76 mm) Thick Panel
      2) Minimum Insulation R-Value: R-20.1
      3) Vinyl Cladding: minimum 38 mil

3.4 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 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.

3.5 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to be welded. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:
   1. Ductwork shall be Type 304 stainless steel.
   2. Ductwork shall be galvanized steel.
      a. If duct outer surface is uninsulated, protect outer surface with suitable paint. Paint materials and application requirements are specified in Section 099113 "Exterior Painting."
   3. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 230713 "Duct Insulation."

3.6 DUCT SEALING

A. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
   1. All ducts to be sealed to comply with (EC C403.11.2.1): Seal Class A

3.7 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.

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.

3.8 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.

3.9 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."

B. EXPOSED DUCTWORK: Verify that cutting oils and lubricants are removed from the ductwork prior to painting to prevent staining of the paint when dry. This includes washing the inside of spiral ductwork prior to hanging.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
   1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
   2. Test the following systems:
      a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
      b. Supply Ducts with a Pressure Class of 2 Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
      c. Return Ducts with a Pressure Class of 2 Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
      d. Exhaust Ducts with a Pressure Class of 2 Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
      e. Outdoor-Air Ducts with a Pressure Class of 2 Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling

no less than 50 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing.
8. Minimum Duct Leakage Testing requirements not listed elsewhere
    a. The following duct systems shall be leak tested in accordance with the SMACNA HVAC Air Duct Leakage Test manual.
    b. 15% of all ductwork below 3” WC.
    c. All duct systems operating at a static pressure in excess of 3” WC.
    d. All concealed vertical duct risers.
    e. All supply ducts upstream of terminal boxes.
    f. All supply/return/exhaust mains.
9. Minimum The duct leakage class shall be as follows (Rectangular/Round) requirements not listed elsewhere:
    a. Pressure class of 2” WC and below: Leakage class 24/12.
    b. Pressure class of 3” WC: Leakage class 12/6.
    c. Pressure class of 4” and above: Leakage class 6/3.

C. Test hood to comply with New York State Mechanical Code section MC506.3.2.5 for grease duct. Provide reports outline compliance with this section.

D. 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 in accordance with "Description of Method 3 - NADCA 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.

E. Duct system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.11 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use duct cleaning methodology as indicated in NADCA ACR.

C. Use service openings for entry and inspection.
1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and

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.

D. 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.

E. 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.

F. 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 in accordance with NADCA ACR. 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 in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.12 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.13 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
   1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

B. Supply Ducts:
   1. Ducts Connected to Fan Coil Units, and Terminal Units:
      a. Pressure Class: Positive 2-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 8
      d. SMACNA Leakage Class for Round and Flat Oval: 4.
   2. Ducts Connected to Constant-Volume Air-Handling Units.
      a. Pressure Class: Positive 3-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 8.
      d. SMACNA Leakage Class for Round and Flat Oval: 4.
   3. Ducts Connected to Variable-Air-Volume Air-Handling Units:
      a. Pressure Class: Positive 4-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 8.
      d. SMACNA Leakage Class for Round and Flat Oval: 4.
   4. Ducts Connected to Equipment Not Listed Above:
      a. Pressure Class: Positive 2-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 8.
      d. SMACNA Leakage Class for Round and Flat Oval: 4.
   5. Ducts exposed outdoors shall be pre-insulated manufacturer ducts including supply air and return air. Refer to OUTDOOR RECTANGULAR DUCT AND FITTINGS SUPPLEMENTAL
   6. Ducts located in the exterior enclosures shall be pre-insulated manufacturer ducts including supply air and return air. Refer to OUTDOOR RECTANGULAR DUCT AND FITTINGS SUPPLEMENTAL

C. Return Ducts:
   1. Ducts Connected to Fan Coil Units, and Terminal Units:
      a. Pressure Class: Positive or negative 2-inch wg.
      b. Minimum SMACNA Seal Class: A
      c. SMACNA Leakage Class for Rectangular: 8.
      d. SMACNA Leakage Class for Round and Flat Oval: 4.
   2. Ducts Connected to Air-Handling Units:
      a. Pressure Class: Positive or negative 3-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 4.
      d. SMACNA Leakage Class for Round and Flat Oval: 2.
   3. Ducts Connected to Equipment Not Listed above:
      a. Pressure Class: Positive or negative 3inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 4.
      d. SMACNA Leakage Class for Round and Flat Oval: 2.

4. Ducts exposed outdoors shall be pre-insulated manufacturer ducts including supply air and return air. Refer to OUTDOOR RECTANGULAR DUCT AND FITTINGS SUPPLEMENTAL
5. Ducts located in the exterior enclosures shall be pre-insulated manufacturer ducts including supply air and return air. Refer to OUTDOOR RECTANGULAR DUCT AND FITTINGS SUPPLEMENTAL

D. Exhaust Ducts:
1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
   a. Pressure Class: Negative 2-inch wg.
   b. Minimum SMACNA Seal Class: Aif negative pressure, and A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 8.
   d. SMACNA Leakage Class for Round and Flat Oval: 4.
2. Ducts Connected to Air-Handling Units
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 4.
   d. SMACNA Leakage Class for Round and Flat Oval: 2.
3. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.
   a. Exposed to View: Type 304, stainless-steel sheet, No. 4
   b. Concealed: Type 304, stainless-steel sheet, No. 2D finish.
   c. Welded seams and joints.
   d. Pressure Class: Positive or negative 3-inch wg.
   e. Airtight/watertight.
4. Ducts Connected to Dishwashers, Dishwasher Hoods, and Other High-Humidity Locations:
   a. Type 304, stainless-steel sheet.
   b. Exposed to View: No. 3 finish.
   c. Concealed: No. 2D finish.
   d. Welded longitudinal seams, welded or flanged transverse joints with watertight EPDM gaskets.
   e. Pressure Class: Positive or negative 3-inch wg.
   f. Airtight/watertight.
5. Ducts Connected to Laundry Dryer and Bathroom Exhaust
   a. Aluminum or Type 304, stainless-steel sheet.
   b. Exposed to View: No. 3 finish.
   c. Concealed: No. 2D finish.
   d. Welded longitudinal seams; welded or flanged transverse joints with watertight EPDM gaskets.
   e. Dryer systems shall have Band Clamps: to allow disassembly and reassembly for cleaning and Provide band clamp connections equivalent to Ductmate Quick-Sleeve for all dryer exhaust ductwork
   f. Pressure Class: Positive or negative 3-inch wg.
   g. Airtight/watertight.
6. Ducts Connected to Equipment Not Listed above:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A if negative pressure; A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 8.
   d. SMACNA Leakage Class for Round and Flat Oval: 4.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A
   c. SMACNA Leakage Class for Rectangular: 8.
   d. SMACNA Leakage Class for Round and Flat Oval: 8.
2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 8.
   d. SMACNA Leakage Class for Round and Flat Oval 4.
3. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular:8.
   d. SMACNA Leakage Class for Round and Flat Oval 4.

F. Intermediate Reinforcement:
   1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.
   2. Outdoor Ducts:
      a. Exposed to Airstream: Match duct material.
      b. Not Exposed to Airstream: Galvanized.
   3. Stainless-Steel Ducts:
      a. Exposed to Airstream: Match duct material.
      b. Not Exposed to Airstream: Match duct material.
   4. Aluminum Ducts: Aluminum.

G. Elbow Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
      a. Velocity 1000 fpm or Lower:
         1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
         2) Mitered Type RE 4 without vanes.
      b. Velocity 1000 to 1500 fpm:
         1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
         2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
         3) 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."
      c. Velocity 1500 fpm or Higher:
         1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
         2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
         3) 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. 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. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

c. 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."

3. 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.
      4) Radius-to Diameter Ratio: 1.5.
   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

H. 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: Conical 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 233113

SECTION 233300 - 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. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Flange connectors.
6. Turning vanes.
7. Duct-mounted access doors.
8. Flexible connectors.
9. Duct accessory hardware.

B. Related Requirements:
1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
2. Section 284621.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.3 REFERENCES

A. AMCA 500 - Test Methods for Louvers, Dampers and Shutters.

B. AMCA 511 - Certified Ratings Program for Air Control Devices.

C. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

D. NFPA 101 – Life Safety Code.

E. UL 555 - Standard for Safety; Fire Dampers.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. 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, 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.
   2. 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.
   3. Source quality-control reports.
   4. Provide a typical mock-up for each type of opening protection Application
      a. Fire Damper
   5. All concerned parties shall review and approve the mock-up before the remaining units are installed.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 DEFINITIONS

A. Range hood, unit, kitchen hood and hood system; for purposes of this specification section, these terms all have the same definition.

B. Residential grade fire suppression: a hood suppression system that fulfills the 300A standard, being designed to protect a residential-grade cooking appliance that is used within a commercial space.

C. Eyebrow, compensating, short circuit, short cycle types are not allowed.

1.7 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.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.9 QUALITY ASSURANCE

A. Dampers shall be warranted against manufacturing defects for a period of 5 years.

B. Dampers shall be tested, rated and labeled in accordance with the latest UL requirements.

C. Damper pressure drop ratings shall be based on tests and procedures performed in accordance with AMCA 500.

D. Mockups:
   1. Provide a mock-up of each type and orientation of fire damper specified, build mockups representing static-pressure classes -2-inch wg. Mock-ups shall be reviewed and approved by the contractor, damper manufacturer’s representative, and the engineer. Build mockups to comply with the following requirements, using materials indicated for the completed Work:
      a. Transverse joints.
      b. Access door(s).
      c. 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 shall become part of the completed Work if undisturbed at time of Substantial Completion.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.

B. Storage: Store materials in a dry area indoor, protected from damage and in accordance with manufacturer's instructions.

C. Handling: Handle and lift dampers in accordance with manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage.

1.11 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.

1.12 FIELD CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with 2020 Mechanical Code of New York State, 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. 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 A653/A653M.
   1. Galvanized Coating Designation G90.
   2. Exposed-Surface Finish: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and No 2 finish for exposed ducts.

D. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

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.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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. Greenheck Fan Corporation.

2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 1250 fpm.

D. Maximum System Pressure: 2-inch wg.

E. Frame: Hat-shaped, 0.063-inch-thick extruded aluminum, or 0.05-inch-thick stainless steel to match system duct material, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, center pivoted maximum 6-inch width, 0.050-inch-thick aluminum sheet noncombustible, tear-resistant, neoprene-coated fiberglass with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:
1. Material: Stainless steel.
2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Aluminum.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:
1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.
   a. Sleeve Thickness: 20 gauge minimum.
   b. Sleeve Length: 6 inches minimum.
6. Screen Material: Aluminum.
7. Screen Type: bird.
8. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
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. Greenheck Fan Corporation.
   b. Nailor Industries Inc.

c. Pottorff.
d. Ruskin Company.

2. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated on Drawings
3. Standard leakage rating, with linkage outside airstream.
4. Suitable for horizontal or vertical applications.
5. Frames:
   a. Frame: Hat-shaped, 0.05-inch-thick stainless 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. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Stainless-steel, 0.064 inch thick.
7. Blade Axles: Stainless steel.
8. Bearings:
   a. Oil-impregnated stainless-steel sleeve.
   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 products by one of the following:
   a. McGill AirFlow LLC.
   b. Nailor Industries Inc.
   c. Pottorff.
   d. Ruskin Company.
2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.
6. Blade Axles: Stainless steel.
7. Bearings:
   a. Stainless-steel sleeve.
   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.
8. Tie Bars and Brackets: Aluminum.

C. Low-Leakage, Steel, Manual Volume Dampers:
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. Arrow United Industries.
   b. Nailor Industries Inc.

c. Pottorff.
d. Ruskin Company.
2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames:
   a. Hat shaped.
   b. 0.05-inch-thick stainless steel.
   c. Mitered and welded corners.
   d. Flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Stainless, roll-formed steel, 0.064 inch thick.
7. Blade Axles: Stainless steel.
8. Bearings:
   a. Oil-impregnated stainless-steel sleeve.
   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. Blade Seals: Neoprene.
10. Jamb Seals: Cambered aluminum.
11. Tie Bars and Brackets: Aluminum.
12. Accessories:
    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:
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. Lloyd Industries, Inc.
   b. Nailor Industries Inc.
   c. Pottorff.
   d. Ruskin Company.
2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
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. Parallel- or opposed-blade design.
   c. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.
7. Blade Axles: Stainless steel
8. Bearings:
   a. Oil-impregnated stainless-steel sleev].
   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. Blade Seals: Neoprene.
10. Jamb Seals: Cambered aluminum.
11. Tie Bars and Brackets: Aluminum.
12. Accessories:
    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

E. 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.

F. 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.

2.5 CONTROL DAMPERS

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. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Dampers shall comply with energy code requirements. Refer to C403.7.7 “Shutoff Dampers , Outdoor air intake and exhaust openings and stairway and shaft vents shall be provided with Class I motorized dampers. The dampers shall have an air leakage rate not greater than 4 cfm/ft2 (20.3 L/s • m2) of damper surface area at 1.0 inch water gauge (249 Pa) and shall be labeled by an approved agency when tested in accordance with AMCA 500D for such purpose.

D. Frames:
1. Hat shaped.
2. 0.05-inch-thick stainless steel.
3. Mitered and welded corners.

E. Blades:
1. Multiple blade with maximum blade width of [6 inches] [8 inches].
2. Opposed-blade design.
3. Aluminum.
4. 0.064 inch thick single skin.
5. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

F. Blade Axles: 1/2-inch-diameter; stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
   1. Operating Temperature Range: From minus 40 to plus 200 deg F.

G. Bearings:
   1. Oil-impregnated stainless-steel sleeve.
   2. 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.
   3. Thrust bearings at each end of every blade.

2.6 FIRE DAMPERS

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. Greenheck Fan Corporation.
   2. Pottorff.
   3. Ruskin Company.

B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing. (High Hat Configuration)

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, galvanized sheet steel; gauge in accordance with UL listing.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.7 FLANGE CONNECTORS

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. Ductmate Industries, Inc.
   2. Elgen Manufacturing.
   3. Ward Industries; a brand of Hart & Cooley, Inc.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gauge and Shape: Match connecting ductwork.

2.8 TURNING VANES

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. Ductmate Industries, Inc.
   2. Duro Dyne Inc.
   3. DynAir; a Carlisle Company.
   4. Elgen Manufacturing.

B. 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.
   1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; 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.

F. Vane Construction: Single wall for ducts up to 36 inches wide and double wall for larger dimensions.

2.9 DUCT-MOUNTED ACCESS DOORS

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. Ductmate Industries, Inc.
   2. Duro Dyne Inc.
   3. Ruskin Company.

B. Duct-Mounted Access Doors:
   1. Rectangular duct
   2. Round or rectangular duct.
   3. Access door for duct cleaning.
   4. Uninsulated access door for duct cleaning.
   5. Round ducts.
   6. Observation Access door

C. Access door for rectangular duct.
   1. Use - To provide easy access into air ducts and units. The door solid, well-insulated, leakproof door.

2. Characteristic
    a. Insulated
    b. Smooth interior finish on insulated doors
    c. Tested to 20” W.G. with no leakage noted
    d. Tested to negative 10” W.G. with no leakage noted
    e. Insulated doors
3. Panels
    a. The insulated Sandwich Access Door consists of three layers of precision stamped steel.
    b. The inside panel consists of two layers of metal which are spot welded together along the rim encapsulating high density fiberglass insulation with Ecose® Technology UL classified FHC25/50.
    c. The 24” x 18” door consists of two layers of precision stamped steel. A polyester foam pad installed between the inner and outer door panels provides insulation.
4. Gasket
    a. Closed cell neoprene gasket is UL94HF1 listed with a service temperature range of (ASTM D746) -20° F to 200° F.
    b. The gasket is bonded to the inside panel of the access door to insure consistent installations.
5. Springs
    a. Zinc plated conical springs are installed, between the inner and outer door, to facilitate opening.
6. Knobs
    a. Red polypropylene molded knobs have threaded metal inserts to eliminate thread stripping.
    b. Knobs are easily turned by hand. Knobs are UL94HB listed.
7. Bolts
    a. Zinc plated carriage bolts are secured to inner door.
8. Template
    a. Self-adhesive template is provided for the exact size of duct opening required

D. Access door for round or rectangular duct.
1. Use
    a. To provide easy access into grease duct or high-temp duct systems.
    b. The door provides a solid, leak resistant door.
2. Characteristic
    a. standard flat and round duct access doors
    b. 16 gauge black iron backing plate
3. Panels
    a. The Hi-Temp Access Door consists of two layers of precision stamped, hot-dipped galvanized steel and one 16 gauge black iron backing plate.
    b. The backing plate is spot welded to the inside panel.
4. Gasket
    a. For Hi-Temperature application fiberglass rope (1000°F max) is permanently bonded to the outside panel of the access door to eliminate leakage.
    b. For Grease Duct application, Ceramic Fiber Gasket (2300°F max -- meets NFPA 96 standards) is permanently bonded to the outside panel of the access door to eliminate leakage.
5. Springs
    a. Zinc plated conical springs are installed, between the inner and outer door, to facilitate opening.

6. Wing Nuts
   a. Zinc coated wing nuts are easily turned by hand.
7. Bolts
   a. Zinc plated carriage bolts are secured to inner door.
8. Template
   a. Self-adhesive template is provided for the exact size of duct opening required

E. Access door for duct cleaning.
1. USE
   a. To provide easy access into air ducts and units.
   b. The door provides a solid, leakproof door that is simple to install.
2. Characteristic
   a. Insulated or Uninsulated
3. Panels
   a. The Circular Access door consists of two layers of precision stamped, hot-dipped galvanized steel.
4. Gasket
   a. Closed cell neoprene gasket is UL94HF1 listed with a service temperature range of (ASTM D746) -20° F to 200° F.
   b. The gasket is permanently bonded to outside panel of the access door to eliminate leakage.
5. Springs
   a. Zinc plated conical springs are installed over the bolts, between the inner and outer door, to facilitate opening
6. Wing Nuts
   a. Zinc coated wing nuts are easily turned by hand without tools.
7. Bolts
   a. Zinc plated carriage bolts are secured to inner door.
8. Insulation
   a. A polyester foam pad installed between the inner and outer panel.

F. Uninsulated access door for duct cleaning.
1. USE
   a. To provide easy access into air ducts and units.
2. Characteristic
   a. Insulated or Uninsulated
3. Panels
   a. The Clean-Out Access door consists of two layers of precision stamped, hot-dipped galvanized steel.
4. Gasket
   a. Closed cell neoprene gasket is UL94HF1 listed with a service temperature range of (ASTM D746) -20° F to 200° F.
   b. The gasket is bonded to the inside of the door to insure consistent installations.
5. Springs
   a. Zinc plated conical springs are installed, between the inner and outer door, to facilitate opening.
6. Wing Nuts
   a. Zinc coated wing nuts are easily turned by hand.
7. Bolts
   a. Zinc plated carriage bolts are secured to inner door.
8. Template

a. Self adhesive template is provided for the exact size of duct opening required.

G. Access door for round ducts.
1. USE
   a. To provide easy access into air ducts and units.
   b. The door provides a solid, leakproof door that is simple to install.
2. Characteristic
   a. Insulated or uninsulated
   b. Smooth interior finish on insulated doors
   c. Tested to 20" W.G. with no leakage noted
   d. Tested to negative 10" W.G. with no leakage noted
   e. Negative pressure applications as gasket is placed to the outside panel
   f. Insulated doors
3. Panels
   a. Insulated Round Duct Access Door consists of three layers of precision stamped steel.
   b. The inside panel consists of two layers of metal which are spotwelded together along the rim, encapsulating high density fiberglass insulation with Ecose® Technology UL classified FHC 25/50
   c. Uninsulated doors have similar construction without the backing plate and insulation.
   d. The 24" x 18" access door consists of only two layers of precision stamped steel. A polyester foam pad installed between the inner and outer door panels provides insulation.
4. Gasket
   a. Closed cell neoprene gasket is UL94HF1 listed with a service temperature range of (ASTM D746) -20° F to 200° F.
   b. The gasket is bonded to the inside of the door to insure consistent installations.
5. Springs
   a. Zinc plated conical springs are installed, between the inner and outer door, to facilitate opening.
6. Knobs
   a. Red polypropylene molded knobs have threaded metal inserts to eliminate thread stripping. Knobs are easily turned by hand. Knobs are UL94HB listed.
7. Bolts
   a. Zinc plated carriage bolts are secured to inner door.
8. Template
   a. Self adhesive template is provided for the exact size of duct opening required.

H. Access door which allows inspection of the inside of the duct without door removal.
1. USE
   a. Provide easy access into air ducts and unit and allow for viewing the inside of the duct.
   b. The door was developed to provide a solid, leakproof door that is simple to install..
2. Characteristic
   a. 4" x 2-5/8" viewport
   b. Safety glass used for window
   c. Tested to 10" W.G.
   d. Insulated or uninsulated
3. Panels

a. The Observation Access Door consists of two layers of precision stamped, hot-dipped galvanized steel.

4. Gasket
5. Closed cell neoprene gasket is UL94HF1 listed with a service temperature range of (ASTM D746) -20° F to 200° F. The gasket is permanently bonded to the inside panel to eliminate leakage.
6. Springs
7. Zinc plated conical springs are installed, between the inner and outer door, to facilitate opening.
   a. Knobs
   b. Red polypropylene molded knobs have threaded metal inserts to eliminate thread stripping. Knobs are easily turned by hand. Knobs are UL94HB listed.
8. Bolts
   a. Zinc plated carriage bolts are secured to inner door.
9. Glass
   a. Safety glass (1/4”) is permanently sealed with silicone.
10. Clips
    a. Hot-dipped galvanized steel clips mechanically fasten the safety glass in place.
11. Template
    a. Self adhesive template is provided for the exact size of duct opening required.

I. 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: Continuous and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.
   d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

2.10 DUCT ACCESS PANEL ASSEMBLIES

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. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Flame Gard, Inc.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0428-inch stainless steel.

D. Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.11 FLEXIBLE CONNECTORS

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. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. DynAir; a Carlisle Company.
4. Ventfabrics, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip [3-1/2 inches] [5-3/4 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.

E. 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.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
1. Minimum Weight: 14 oz./sq. yd..
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor 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. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.12 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 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 and smoke dampers according to UL listing.

H. 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. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.

4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke 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.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream and downstream from turning vanes.
9. Control devices requiring inspection.
10. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:
1. One-Hand or Inspection Access: 12 by 12 inches.
2. Two-Hand Access: 12 by 12 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Install duct test holes where required for testing and balancing purposes.

O. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 REQUIREMENTS

A. Dampers
1. Control, Backdraft, and Pressure Relief Dampers:
   a. All dampers shall have motorized actuators and shall not be gravity operated.
2. Manual Volume Dampers:
   a. Provide manual volume dampers in supply, return and exhaust systems for balancing. The use of opposed blade dampers mounted directly behind air devices shall not be used as primary means of balancing. Volume dampers shall be shown in plan and their installation shall be detailed. In general, provide volume dampers at the following locations.
      1) At the branch to each supply, return and exhaust diffuser/register/grille.
      2) At all sub-mains.
      3) At all duct connections to vertical risers.

4) At other locations deemed appropriate for system balancing.
5) The use of remote operators shall be avoided.

3. Dampers shall be constructed of same material as the associated ductwork.
4. Provide stand-off hardware for insulated ducts.
5. Provide a locking device and damper position indicator.
6. Seal duct penetrations consistent with duct pressure and seal class.
7. Contractor and Inspector shall record all relevant inspection information regarding each damper installation. Utilize a tracking chart for fire damper, smoke damper, and combination fire smoke damper. A sample chart is shown below; other chart may be used if approved by the Owner

B. Fire Dampers:
1. Fire dampers shall be the dynamic type and UL 555 listed.
2. Fire dampers shall be of the Type B design with the blades located outside of the airstream.

C. Duct Mounted Access Doors
1. Duct mounted access doors shall be fabricated and installed in accordance with the most recent edition of SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".
2. In general, duct mounted access doors shall be constructed to match the associated ductwork relative to the materials of construction, pressure classification, and seal class.
3. Duct mounted access doors shall be insulated double wall construction.

D. Air Devices
1. Air devices shall be constructed of aluminum or steel as appropriate for the intended service and location. Aluminum construction shall be used in wet or humid environments including bathrooms, shower rooms, etc.
2. All air devices shall be provided with opposed blade volume dampers provided at each duct branch.
3. Rectangular and square ceiling diffusers shall have a louvered face with airflow and throw patterns coordinated with the intended location.
4. Perforated diffusers shall be provided with an adjustable pattern controller located behind a perforated face plate. The face plate shall be flush with the adjacent ceiling.
5. In general, supply registers and grilles shall be double deflection with adjustable face blades. Provide opposed blade dampers for all branch ductwork or at registers if it is not possible to provide dampers at branches.
6. In general, return and exhaust registers and grilles shall have 45-degree fixed face blades. Provide opposed blade dampers for all branch ductwork or at registers if it is not possible to provide dampers at branches.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Create mock up installation for each type of fire damper wall penetration assembly. All concerned parties must review and approve the mock up prior to the remaining unit installations.
2. Operate dampers to verify full range of movement.
3. Inspect locations of access doors and verify that purpose of access door can be performed.

4. Operate fire dampers to verify full range of movement and verify that proper heat-response device is installed.
5. Inspect turning vanes for proper and secure installation.
6. Operate remote damper operators to verify full range of movement of operator and damper.
7. Test for leakage of unfiltered air while system is operating.
8. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

B. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of eight (8) hours of instruction at the site, during start-up.
   3. Provide four (4) hours of instruction at the site after start-up
      a. Provide two (2) hours at three (3) months after start-up training
      b. Provide one (1) hour at six (6) months after start-up training.
      c. Provide one (1) hour at nine (9) months after start-up training

END OF SECTION 233300

SECTION 233346 - FLEXIBLE 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. Insulated flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For flexible ducts.
   1. Include plans showing locations and mounting and attachment details.
   2. 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.

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.

C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."

2.2 INSULATED FLEXIBLE DUCTS

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. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Thermaflex; a Flex-Tek Group company.

B. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film 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 10 to plus 160 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1 R8.

C. 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/IES 90.1 R8.

D. Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil; fibrous-glass insulation; polyethylene vapor-barrier film.

1. Pressure Rating: 8-inch wg positive or negative.
2. Maximum Air Velocity: 5000 fpm.
3. Temperature Range: Minus 20 to plus 250 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1 R8.

2.3 FLEXIBLE DUCT CONNECTORS

A. 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.

B. Non-Clamp Connectors: Adhesive plus sheet metal screws.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible ducts 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 in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

D. Connect diffusers or light troffer boots to ducts directly or with maximum 36-inch lengths of flexible duct clamped or strapped in place.

E. Connect flexible ducts to metal ducts with liquid adhesive plus draw bands or adhesive plus sheet metal screws.

F. Install duct test holes where required for testing and balancing purposes.

G. Installation:
   1. Install ducts fully extended.
   2. Do not bend ducts across sharp corners.
   3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
   4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
   5. Install flexible ducts in a direct line, without sags, twists, or turns.

H. Supporting Flexible Ducts:
   1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
   2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
   3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
   4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

END OF SECTION 233346

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Centrifugal ventilators - roof downblast.
   2. Sidewall propeller fans.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
   2. Rated capacities, operating characteristics, and furnished specialties and accessories.
   3. Certified fan performance curves with system operating conditions indicated.
   4. Certified fan sound-power ratings.
   5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   6. Material thickness and finishes, including color charts.
   7. Dampers, including housings, linkages, and operators.
   8. Prefabricated roof curbs.
   9. Fan speed controllers.

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.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and emergency operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.2 CENTRIFUGAL VENTILATORS - ROOF DOWNBLAST

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Greenheck Fan Corporation.
   2. Loren Cook Company.
   3. PennBarry; division of Air System Components.

B. Housing: Downblast; removable spun-aluminum dome top and outlet baffle; square, one-piece aluminum base with venturi inlet cone.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Accessories:
   1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
   3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
   4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
   5. Spark-resistant, all-aluminum wheel construction.
   6. Mounting Pedestal: Galvanized steel with removable access panel.

E. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
   1. Overall Height: 18 inches.

2.3 SIDEWALL PROPELLER FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Greenheck Fan Corporation.
   2. Loren Cook Company.
   3. PennBarry; division of Air System Components.

B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.

C. Fan Drive, Direct: Direct-drive motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

D. Accessories:
   1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

2. Motorized Dampers: Parallel-blade dampers with electric actuator wired to close when fan stops.
3. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
4. Wall Sleeve: Galvanized steel to match fan and accessory size.
5. Weathershield Hood: Galvanized steel to match fan and accessory size.
6. Weathershield Front Guard: Galvanized steel with expanded metal screen.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
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.

2.5 SOURCE QUALITY CONTROL

A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.

B. AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install power ventilators level and plumb.

B. Equipment Mounting:
1. Secure roof-mounted fans to roof curbs with zinc-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.
2. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK 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."

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
   1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 STARTUP SERVICE:

A. Perform startup service.
   1. Complete installation and startup checks in accordance with 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 ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   4. Verify that cleaning and adjusting are complete.
   5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
   6. For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   7. Adjust belt tension.
   8. Adjust damper linkages for proper damper operation.
   9. Verify lubrication for bearings and other moving parts.
   10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   11. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
   12. Shut unit down and reconnect automatic temperature-control operators.
   13. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Contractor will 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.
   1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Test and adjust controls and safeties.
   3. Fans and components will be considered defective if they do not pass tests and inspections.
   4. Prepare test and inspection reports.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233423

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SECTION 233600 - 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. Modulating, single-duct air terminal units.
   2. Integral heating coils.
      a. Hot water.
   3. Integral terminal unit controls.
      a. Direct digital.

1.3 REFERENCES

A. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

B. UL 181 - Factory-Made Air Ducts and Connectors.

C. UL 1995, Heating and Cooling Equipment.

D. CUL C22.2 No. 236, Heating and Cooling Equipment.

E. AHRI 880 - Air-Conditioning and Refrigeration Institute Standard Rating Conditions for Air Terminals.

F. AHRI 885 - Air-Conditioning, Heating and Refrigeration Institute Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.

G. ASTM A 527 (Steel Sheet, Zinc Coated Galvanized).

1.4 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. Shop Drawings: For air terminal units.
   1. Include plans, elevations, sections, and mounting details.

a. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Include diagrams for power, signal, and control wiring.
c. Hangers and supports, including methods for duct and building attachment and vibration isolation.

2. Submit shop drawings and product data sheets indicating configuration, general assembly, and materials used in fabrication.
3. Submit product performance data indicating design air flow, minimum airflow, minimum static pressure drop.
4. Submit sound power in accordance with AHRI Standard 880 2017 and noise criteria (NC) values, in accordance with AHRI Standard 885 2008, for radiated and discharge paths.
5. Unit maximum sound power levels in each octave band with 0.750 in H2O inlet pressure and specified design discharge and air volume scheduled shall not exceed the scheduled radiated and discharge sound power levels for each respective unit. No credit or reduction shall in any way be considered for room, plenum, ceiling, sound attenuator, and/or similar item effects.

C. 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.
4. 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

1.7 QUALIFICATIONS

A. Manufacturer: The company manufacturing the products specified in this section shall have a minimum of ten year experience producing products of this type.

B. SYSTEM RESPONSIBILITY

C. The contractor shall be responsible for any and all costs associated with any and all changes resulting from the use of a supplier other than the one used as "basis of design".

D. The duct system is computer designed for air balance and noise control using the performance data of the listed manufacturer. Substituting another VAV terminal unit manufacturer may require changes in the system design. These changes may include, but are not limited to, changes in ductwork size or layout, fittings, controls, building structure and piping. The installing contractor, upon substituting an approved alternate, must submit a computerized duct design showing system pressure requirements and acoustic data for the complete duct layout.

E. The VAV system, including terminal units, direct digital controls and ATC/Building Management System shall be furnished by a single manufacturer who shall be responsible for system performance. If the terminals unit supplier is different from the control system supplier, then one of the two suppliers must bear sole responsibility for proper system performance. The supplier bearing responsibility shall be identified at the time of submittal.

1.8 WARRANTY

A. Provide manufacturer's parts warranty for one year from unit start-up or eighteen months from unit shipment, whichever is shorter.

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 MANUFACTURERS

A. Manufacturer shall participate in the AHRI Certification program. Unit performance data shall be rated in accordance with AHRI Standard 880. The manufacturer shall display the AHRI Symbol on all units.

B. Specified 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. Trane
   2. Environmental Technologies Inc.
   3. Titus
   4. Tempmaster
   5. Daikin

2.3 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

A. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

B. Casing: 0.040-inch- thick galvanized steel, single wall.

C. Single duct terminal units.
   1. Ceiling mounted primary air control terminal units for connection to a single 5 in. w.g. maximum pressure duct of a central air distribution system. Terminals units may be provided with controls and integral heating coils.
   2. Identify each terminal unit with clearly marked identification label and airflow indicator. Label shall include unit nominal air flow, maximum factory-set air flow, minimum factory-set air flow, and coil type.

2.4 FABRICATION

A. Casings: Units

B. shall be completely factory-assembled, manufactured of corrosion protected steel, and fabricated with a minimum of 18-gauge metal on the high pressure (inlet) side of the terminal unit damper and 22-gauge metal on the low pressure (outlet) side and unit casing.

C. Insulation: Double-wall - The interior surface of unit casing acoustically and thermally lined with a minimum of 1-inch, 1.0 lb/ft3 (25.4 mm, 16.0 kg/m3) composite density glass fiber with a high-density facing. Minimum insulation R-Value of 3.85. Insulation shall meet NFPA-90A and UL 181 requirements. The insulation is covered by an interior metal liner made of 26 gauge galvanized steel. The interior metal liner shall isolate the fiberglass insulation from the airstream and allow for cleaning of the terminal unit interior surfaces. All cut edges of the insulation are covered by metal flanges. There are no exposed edges of insulation (complete metal encapsulation). All wire penetrations through the interior metal liner shall be covered by grommets.

D. Assembly: Primary air control damper, airflow sensor, controls and optional heating coil in single assembly.

E. Access Panels: Casing shall be provided with integral sound attenuator and dual wall fully insulated bottom access panel with camlock style latches.

F. Rectangular Supply Air Outlet Connections: Rectangular outlet connections for units without optional heating coils on the outlet of the terminal unit shall be flange type. Rectangular outlet connections for units with optional heating coils on the outlet of the terminal unit shall be slip and drive type.

G. Unit air inlet and outlet openings shall ship from manufacturer with removable sealed covering. Covering shall not constrain the unit installation process.

2.5 PRIMARY AIR CONTROL DAMPER ASSEMBLY

A. Construct damper assembly from a minimum of 18 gauge galvanized steel on the primary air side of the terminal. Blade shall incorporate a full closed cell damper seal to minimize leakage. Damper blade shall be a minimum of 0.10 in. thickness. Maximum damper leak rate shall not exceed 1% of damper nominal CFM at 4 in. wg. differential pressure.

B. Damper assembly shall be constructed self-lubricating bearings and contain a mechanical stop.

C. Primary Damper Shaft shall have a position indicator stamped on the end of the shaft to identify damper position without disassembly of duct, unit casing, or removal of the control box cover.

D. Provide damper assembly with integral flow sensor. Flow sensor shall be provided regardless of control type. Flow sensor shall be a 16-point (minimum 8-points on high pressure side and 8-points on low pressure side), averaging ring or cross type. Bar or single point sensing type is not acceptable. Damper assembly shall be capable of maintaining airflow to within +/- 5 percent of rated unit airflow setpoint with 1.5 duct diameters straight duct upstream from the unit.

E. Flow sensor transducer shall not be integral to the unit controller.

F. Flow coefficient calibration data shall be provided for each terminal unit at or near the unit inlet.

G. Integral flow sensor pressure transducer shall be pressure tested, with air, prior field installation.

H. Terminal unit manufacturer shall provide and factory install DDC damper actuator direct coupled to primary air control damper assembly shaft. Damper actuator shall be a 3-wire 24-VAC/DC floating-point quarter turn control device with a constant drive rate independent of load a rated, a rated torque of 45 in.-lb, a 95-second drive time, and an external gear release.

2.6 HEATING COILS

A. Coils shall be factory-installed on the unit discharge and shall consist of aluminum plated fins and seamless copper tubes. The coils shall be 1 or 2-rows with 144 aluminum-plated fins per foot or 3 or 4-rows with 120 aluminum-plated fins per foot. Fins shall have full fin collars to provide accurate fin spacing and maximum fin-to-tube contact. The 3/8" OD tubes shall be mechanically expanded into the fin collars. Coils shall be leak tested at 300 psig air pressure under water and proof tested under water to 450 psig pressure or equivalent tracer gas testing. Supply and return water connections shall be on the same side of the coil and independent of handing to allow jobsite determination of handing. Coil connections shall be brazed. Coil shall have gasketed access panels, on the inlet side attached with screws suitable for cleaning the inlet coil face without disconnecting the coil from the main unit.

B. Capacity: Provide coils in capacities as scheduled on the drawings.

2.7 WIRING

A. Factory install and wire terminal unit. Install electrical components in control box with removable cover. Incorporate single point electrical connection to power source.

B. Disconnect switch - Provide terminal units with a factory installed and wired switch to disconnect power to the unit.

C. Power Line Fuse - Provide single and dual duct terminal units with integral power line fusing installed in the control box to prevent overcurrent damage to the unit.

2.8 DIRECT DIGITAL VAV CONTROLS

A. VARIABLE AIR VOLUME (VAV) TERMINAL UNIT CONTROL.

1. General: DDC Controls, actuator and factory costs to mount, calibrate and test the system shall be the responsibility of Section 159xx Air Terminal Controller (ATC)/Building Management System Contractor.
2. Terminal unit manufacturer shall provide price for factory mounting, continuity check, calibrating, and testing of direct digital controls to the ATC contractor. Field mounted DDC controls are not acceptable.
3. Each Air Terminal shown on the plans shall include a factory mounted and wired Air Terminal Controller (ATC). Each ATC shall include a microprocessor based controller and shall be an integral part of the equipment. The ATC shall control each function of its associated terminal. All application software shall be resident in the ATC's memory and shall be factory pretested and preconfigured. Each ATC shall be programmed based on inlet size with tested proven airflow coefficients provided by terminal unit manufacturer. ATC shall be programmed with airflow set points based on scheduled performance: minimum ventilation airflow, minimum heating airflow, maximum airflow.
4. The ATC shall be fully tested. All features shall be tested including fan and reheat stage energization, air valve modulation, and ATC inputs and outputs. Each terminal unit shall bear a label containing the following information or ATC)/Building Management System Contractor must provide a report containing the following information:
    a. Unit serial number and tag
    b. Minimum and maximum primary airflow
    c. Test equipment identifier and test complete date
    d. Identifier of control algorithm loaded
5. Terminal unit manufacturer or ATC/Building Management System Contractor shall provide test report for each unit upon request identifying tests executed and passed.
6. The ATC shall provide stand-alone operation but shall include the inherent capability to being added on a network without the addition of any hardware. Systems that require an intermediate controller shall not be acceptable. The ATC shall not require a battery. All configuration data shall be stored indefinitely in non-volatile memory. Systems that require a battery to store data are not acceptable.
7. The ATC shall be mounted in a standard NEMA type enclosure, attached to the unit as required by local and national electrical codes. The control, shall be UL or ETL listed to comply with UL Standard 1995 Heating and Cooling Equipment. All electrical components and control transformers shall be factory mounted and wired inside the control box, or the electric heater, as applicable.
8. The ATC shall meet the following communication requirements.
    a. Communicate to System Controller via BACnet MS/TP.
    b. To allow maximum communications speed and co-existence with other controllers, the controller shall support at a minimum the following BACnet MS/TP master baud rate: 9600, 19200, 38400, 76800, and 115200.
    c. To ensure integration to the installed system and additions the controller must be BTL Testing Lab listed for the following:

1) Advance Applications Controller (B-AAC).
2) Application Specific Controller (B-ASC) and Supports sending alarm/event notifications to a subscriber.

9. Each ATC shall include the ability to maintain a 365-day clock with holiday functions and shall also support network broadcasts of time for clock synchronization. Each ATC shall provide the capability to provide occupancy scheduling from its own local time schedule, or a time schedule within another controller on the network. Timed override requests through the space temperature sensor override button shall be performed by each ATC without any network requirement. The ATC shall be capable of interfacing to a portable PC for configuring, altering the configuration or airflow setpoints, setting address, uploads, downloads, etc.
10. All terminals that are serviced by a common air handler shall be "LINKED" together to form a single virtual load and operate in unison as a complete system. One ATC shall be designated as a Coordinator between the Air Handler Controller and its associated terminals. The networked ATC(s), through the Coordinator, shall interface with a controller installed on the ventilation air source. The ventilation air system interface shall be a factory supplied microprocessor based controller that allows total closed loop system control as defined in section 2.1.9.A. The Building Control System communications network and factory provided software shall allow dynamic interaction (linkage) of the air terminals with the ventilation air source to create a complete Air Distribution System (ADS) as later described within this specification. The bus that serves the ATC(s) and air source shall include the ability to run at 38.4K BPS, as a minimum.
11. Systems that do not include inherent linkage software shall state such in their bid/proposal.
12. Alarm/Alert Processing - The ATC shall contain routine(s) to process alarms and alerts. Alarm/alert processing shall consist of a scan of all applicable point types and operating conditions. Certain analog alarms/alerts shall only be monitored when the ATC is in the occupied mode (i.e., relative humidity, Indoor air quality sensor, etc.). Time delays shall be provided with the software to prevent nuisance alarms/alerts during a transition period or if a setpoint change occurs. All alarms/alerts shall be displayed at a portable PC and via the network to a remote EMS operator's station or alarm printer as applicable.
13. The ADS system shall contain a routine to process alarms. Alarm processing shall consist of a scan of all input points.
14. The ATC shall be shipped with factory entered default alarm thresholds. Alarm processing logic shall also monitor return to normal conditions as part of the alarm scan routine.
15. Wireless communication interface capability for future wireless thermostat/sensor.

2.9 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. 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.
   3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
      a. Adhesive shall have a VOC content of 80 g/L or less.

2.10 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 GENERAL REQUIREMENTS

A. The coil shall be provided with an air vent and drain.

B. The coil temperature and pressure rating shall be suitable for the specific system design.

C. The VAV terminal units shall be insulated with a foil faced fiber glass insulation or a closed cell insulation provided it complies with the flame spread/smoke developed ratings required by the 2020 Building Code of New York State.

D. The VAV terminal unit enclosures shall be constructed of G60 galvanized-steel.

E. In general, controls shall be DDC furnished by the control system manufacturer for factory installation by the VAV terminal unit manufacturer.

F. VAV terminals shall be provided with two-way modulating control valves controlled through the building control system.

G. Units shall be arranged for variable volume, two position or constant volume operation as required for the specific application.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.3 ADJUSTING

A. Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design air flow to 25 percent nominal air flow for cooling only units and 30 percent for units with heating coils.

3.4 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.

3.5 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.

3.6 PIPING 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.

3.7 DUCTWORK CONNECTIONS

A. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

B. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.8 ELECTRICAL CONNECTIONS

A. Install field power to each air terminal unit electrical power connection. Coordinate with air terminal unit manufacturer and installers.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

E. 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."

3.9 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."

3.10 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.

3.11 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.

3.12 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.
7. Verify that BAS Graphics read each VAV status and controls it.

3.13 DEMONSTRATION AND TRAINING

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

C. The following training shall be accomplished after the completion of each phase
1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
2. Provide a total of four (4) hours of instruction at the site, during start-up.
3. Provide four (4) hours of instruction at the site after start-up
    a. Provide two (2) hours at three (3) months after start-up training
    b. Provide one (1) hour at six (6) months after start-up training.
    c. Provide one (1) hour at nine (9) months after start-up training

END OF SECTION 233600

SECTION 233713.13 - AIR DIFFUSERS

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. Rectangular and square ceiling diffusers.
2. Round Ceiling Diffusers
3. Perforated diffusers.
4. High-capacity drum louver diffusers.

B. Related Requirements:
1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
2. Section 233713.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.
3. Section 233713.43 "Security Registers and Grilles" for security registers and security grilles.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
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 Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

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.

PART 2 - PRODUCTS

2.1 RECTANGULAR AND SQUARE CEILING

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. Anemostat Products; a Mestek company.
2. Krueger-HVAC, a division of Air System Components; Johnson Controls, Inc.
3. Price Industries.
4. Titus, a division of Air System Components; Johnson Controls, Inc.

B. Basis of Design: Furnish and install Anemostat Model PG Paragon square plaque diffuser of sizes and mounting types designated by the plans and air distribution schedule.

C. Features
1. Center plaque has smooth, hemmed edges for rigidity and flat appearance
2. Steel or Aluminum construction
3. Plaque is assembled without welding or heat – no blemishes
4. Smooth outer cone is die stamped (no mitered corners) and contoured to minimize sound and pressure loss
5. Removable plaque assembly without use of tools. 4 posts interlock into outer cone.
6. Arctic White baked-on finish

D. Construction:
1. Anemostat Model PG Paragon plaque ceiling diffusers. The diffuser sizes shall be nominal 24” x 24” or 12” x 12”, with minimum 18” or 9” square appearance panels.
2. Constructed from steel or extruded aluminum based on the environment installed.
   a. Steel in non humid areas
   b. Aluminum or Stainless steel in moist humid areas (Bathrooms, Toilet Rooms, Shower Rooms).
3. Integrate with the specified ceiling system type.
4. The diffuser shall consist of a back pan and a removable, heavy gauge appearance panel attached to the back pan via (4) positive locking posts.
5. The appearance panel shall have aerodynamic, rigid, hemmed edges around the perimeter and shall be a single piece construction.
6. The panel shall be flat, smooth, and shall be free of any welding or forming blemishes.
7. The horizontal air discharge pattern shall be 360° type.
   a. Blank-off baffles shall be provided to obtain 1,2, or 3 way blow patterns
   b. The size and elevation of the appearance panel.
8. Provide volume control, model VD butterfly type dampers as scheduled. Dampers shall be adjustable from the face.
9. Diffuser finish shall be color as selected by the Architect.

E. Sizes
1. 6” neck 12”x12” Range 50 CMF to 100 CFM, NC <20
2. 8” neck 12”x12” Range 120 CFM to 250CFM, NC <20
3. 10” neck 12”x12” Range 260 CMF to 320 CFM, NC <20
4. 6” neck 24”x24” Range 50 CMF to 170 CFM, NC <20.
5. 8” neck 24”x24” Range 180 CMF to 290 CFM, NC <20
6. 10” neck 24”x24” Range 300 CFM to 400 CFM, NC <20

7. 12” neck 24”x24” Range 410 CMF to 600 CFM, NC <20 to 25
8. 14” neck 24”x24” Range 610 CMF to 900 CFM, NC <20 to 28
9. 16” neck 24”x24” Range 910 CMF to 1000 CFM, NC <20.

F. Accessories:
   1. Opposed Blade Damper:
      a. Supplied with an opposed blade volume control damper of the same material as the grille.
      b. The damper shall be operable from the grille face.

G. Mounting: Surface or T-bar.

2.2 ROUND CEILING DIFFUSERS

A. Devices shall be specifically designed for variable-air-volume flows.

B. Material: Steel.

C. Finish: Anodized aluminum.

D. Face Style: Four or Three cone.

E. Mounting: Duct connection.

F. Pattern: Fully adjustable.

G. Dampers: Butterfly.

H. Accessories:

   1. Equalizing grid.
   2. Plaster ring.
   3. Safety chain.
   4. Sectorizing baffles.
   5. Operating rod extension.

2.3 PERFORATED DIFFUSERS

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. Krueger-HVAC, a division of Air System Components; Johnson Controls, Inc.
   2. Price Industries.
   3. Titus, a division of Air System Components; Johnson Controls, Inc.

B. Features
   1. Steel construction with baked-on Arctic white finish (entire assembly)
   2. Back pan with integral earthquake loops
   3. Removable perforated face uses concealed spring clips. Pattern is 3/16” diameter holes on 1/4” centers, 50% free area.

4. 5 frame styles for lay-in T-bar, surface mount, concealed spline, tegular, and 9/16" narrow slot suspended grid systems
5. Factory attached, opposed blade volume control damper
6. Aluminum models constructed from extrusion

C. Construction:
1. Perforated exhaust grilles
2. The perforated face pattern shall be 3/16" diameter holes on 1/4" centers with a 51% free area.
3. Constructed from steel or extruded aluminum based on the environment installed.
   a. Steel in non humid areas
   b. Aluminum or Stainless steel in moist humid areas (Bathrooms, Toilet Rooms, Shower Rooms).
4. Corners shall be welded or staked for neat, uniform mitered corners.
5. Ceiling Mount:
   a. Provide 24"x24" panel for lay in ceiling to mount grill in ceiling system.
   b. Hard ceilings surface mount: Frame mounting holes shall be countersunk for oval head screws, provided by the grille manufacturer.
6. Finish shall be baked-on Anemostat Arctic White or custom color as specified by the Architect.

D. Sizes
1. Size 8"x8" Range 50 CMF to 100 CFM, NC <20
2. Size 10"x10" Range 120 CFM to 250CFM, NC <20
3. Size 10"x10" Range 260 CMF to 320 CFM, NC <20
4. Size 12"x12" Range 330 CMF to 500 CFM, NC <20.
5. 6" neck 24"x24" Range 50 CMF to 150 CFM, NC <20
6. 8" neck 24"x24" Range 160 CMF to 280 CFM, NC <20
7. 10" neck 24"x24" Range 290 CFM to 400 CFM, NC <20
8. 12" neck 24"x24" Range 410 CMF to 550 CFM, NC <20
9. 14" neck 24"x24" Range 560 CMF to 750 CFM, NC <20
10. 16" neck 24"x24" Range 790 CMF to 1000 CFM, NC <20.

E. Accessories:
1. Opposed Blade Damper:
   a. Supplied with an opposed blade volume control damper of the same material as the grille.
   b. The damper shall be operable from the grille face.
2. Extension Panel
   a. For lay in ceilings, provide extension panel to grid for non 24"x24" ceiling panels.
   b. Install grille in panel and trim panel to fit ceiling grid dimensions.
3. Equalizing grid.
4. Plaster ring.

2.4 HIGH-CAPACITY DRUM LOUVER DIFFUSERS

A. Airflow Principle: Extended distance for high airflow rates.

B. Material: Aluminum, heavy gage extruded.

C. Finish: Clear Anodized.

D. Border: 1-1/4-inch width with countersunk screw holes.

E. Gasket between drum and border.

F. Body: Drum shaped; adjustable vertically.

G. Blades: Individually adjustable horizontally.

H. Mounting: Surface to duct.

I. Accessories:

1. Opposed-blade steel damper.

2. Duct-mounting collars with countersunk screw holes.

2.5 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers 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 are 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 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. Install diffusers 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 to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.13

SECTION 233713.23 - 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. Fixed face grilles.

B. Related Requirements:
   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
   2. Section 233713.13 "Air Diffusers" for various types of air diffusers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   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. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
   3. Samples: For each exposed product and for each color and texture specified. Smallest size register and grille indicated.
   4. Samples for Initial Selection: For registers and grilles with factory-applied color finishes. Smallest size register and grille indicated.
   5. Samples for Verification: For registers and grilles, in manufacturer's standard sizes to verify color selected. Smallest size register and grille indicated.
   6. 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:
   7. Ceiling suspension assembly members.
   8. Method of attaching hangers to building structure.
   9. Size and location of initial access modules for acoustical tile.
   10. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   11. Duct access panels.
   12. Source quality-control reports.

PART 2 - PRODUCTS

2.1 GRILLES

A. Fixed Blade Face Grille
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. Krueger-HVAC, a division of Air System Components; Johnson Controls, Inc.
   b. Price Industries.
   c. Titus, a division of Air System Components; Johnson Controls, Inc.
2. Features
   a. Fixed blade return grilles and registers exceeding the industry standard using heavy, 20 gauge steel frames
   b. Aerodynamic blade design resulting in lowest achievable sound and pressure levels
   c. 3/4" spacing of blades
   d. Front blades selected as horizontal for visual effect
   e. Registers include a factory attached, opposed blade volume control damper
   f. Mounting holes in frame neatly countersunk for supplied #8 x 1-1/2" oval head screws
   g. Arctic White baked-on finish
3. Construction:
   a. Blades shall be on 3/4" spacing, and shall run horizontal
   b. Blades shall be positioned at 45° deflection angles, and held rigidly fixed in place by rear mullions welded to the grille frame.
   c. Corners shall be welded or staked for neat, uniform mitered corners.
   d. Mounting
      1) Wall
         a) Surface Mount: Frame mounting holes shall be countersunk for oval head screws, provided by the grille manufacturer.
      2) Ceiling Mount:
         a) Provide 24”x24” panel for lay in ceiling to mount grill in ceiling system.
         b) Hard ceilings surface mount: Frame mounting holes shall be countersunk for oval head screws, provided by the grille manufacturer.
   e. Finish shall be baked-on Arctic White or custom color as specified by the Architect.
   f. Sizes
      1) Size 8”x8” Range 50 CMF to 100 CFM, NC <20
      2) Size 12”x6” Range 120 CFM to 250CFM, NC <20
      3) Size 12”x12” Range 260 CMF to 400 CFM, NC <20
      4) Size 16”x10” Range 410 CMF to 600 CFM, NC <20.
4. Accessories:
   a. Opposed Blade Damper:
      1) The register shall be supplied with an opposed blade volume control damper of the same material as the grille.
      2) The damper shall be operable from the grille face.
   b. Border Style:

1) The grille shall be suitable for sidewall mounting, complete with a border in the following:
   a) Surface Mount with 1-1/4 inch flat border.

c. Mounting Frames:
   1) The grille shall be supplied with a 3/8 inch flat border mounting frame.

d. Fastening:
   1) The grille shall be supplied with the following fastening method:
      a) Concealed fastening.
      b) No screw holes.

5. Paint Specification:

a. All components shall have a baked-on powder coat finish.
   1) The paint finish must demonstrate no degradation when tested in accordance with ASTM D1308 (covered and spot immersion) and ASTM D4752 (MEK double rub) paint durability tests.
   2) The paint film thickness shall be a minimum of 2.0 mils.
   3) The finish shall have a hardness of 2H.
   4) The finish shall withstand a minimum salt spray exposure of 1000 hours with no measurable creep in accordance with ASTM D1654, and 1000 hours of exposure with no rusting or blistering as per ASTM D610 and ASTM D714.
   5) The finish shall have an impact resistance of 80 inch-pounds.

2.2 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate 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 registers and grilles are 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 registers and grilles level and plumb.

B. Outlets and Inlets Locations: 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. Install 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 registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.23

SECTION 236333 - EVAPORATIVE ADIABATIC CONDENSERS

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 factory-assembled and tested, induced draft evaporative adiabatic condensers.

B. Furnish and install Air-Cooled Dry Coolers with Adiabatic Cooling System arranged for vertical flow (induced draft), conforming in all aspects to the specifications, schedules and as shown on the plans.
   1. The unit shall use wetted heat transfer media to adiabatically cool the air stream entering the dry, finned coil and shall distribute and manage the water flow to keep dry the finned coil to contain the water within the unit. hydroBLU™ technology shall be employed to determine the precise amount of water feed needed for maintaining performance.
   2. Units that wet the coil or spray water shall not be allowed
   3. Units designed to distribute water directly on finned coil or baffles shall not be acceptable.
   4. Unit shall provide 100% of the heat rejection capacity at the design temperatures while operating without water when the ambient temperature is below the specified switch point temperature as scheduled

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. 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.

C. DDC: Direct digital control.

1.4 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 evaporative refrigerant condenser.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories, including:
      a. Maximum flow rate.
      b. Minimum flow rate.

c. Drift loss as percentage of design flow rate.
d. Sound power levels in eight octave bands for operation with fans off, fans at minimum speed, and fans at design speed.
e. Performance curves for the following:
   1) Varying entering-water temperatures from design to minimum.
   2) Varying ambient wet-bulb temperatures from design to minimum.
   3) Varying water flow rates from design to minimum.
   4) Varying fan operation (off, minimum speed, and design speed).
f. Fan airflow, brake horsepower, and drive losses.
g. Motor amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
h. Electrical power requirements for each evaporative refrigerant condenser component requiring power.

B. Shop Drawings: For evaporative refrigerant condensers.
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.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from Installers of the items involved.

B. Field quality-control reports.

C. Sample Warranties: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For evaporative refrigerant condensers to include in emergency, operation, and maintenance manuals.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

1.8 QUALITY ASSURANCE

A. The cooler manufacturer shall have a Management System certified by an accredited registrar as complying with the requirements of ISO 9001:2008 to ensure consistent quality of products and services. Manufacturers that are not ISO 9001:2008 Certified shall not be acceptable

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of evaporative refrigerant condensers that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Fan, motor, drive shaft, bearings, and motor supports.
      b. Tube bundle.
   2. Warranty Period: Five year(s) from date of Substantial Completion.
   3. Provide factory authorized winterization and summer startup service and maintenance as part of the chiller service during the warranty period.
   4. Provide a complete set of replacement adiabatic pads for all coolers for owner's stock.

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 heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Comply with NFPA 70.

D. ASHRAE Compliance:
   1. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1.

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

2.2 INDUCED-DRAFT EVAPORATIVE REFRIGERANT CONDENSERS

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. Baltimore Aircoil Company.
   2. Guntner by Traner.
   3. Marley
   4. Nimbus.
   5. Basis of Design Unit : Guntner by TraneModel S-GFD 090.1D/2X9-N21J/2P.M

B. Construction Details
   1. Product
      a. The cooler shall consist of an Adiabatic Cooling System, a heat exchanger, powder coated galvanized steel casing, and one or more low noise axial fans with maintenance-free motors.
      b. The Adiabatic Cooling System shall consist of evaporative cooling pads, humidity and ambient temperature sensor, GHM water metering controller, a water distribution and collection system with flow control valve, flow meter, strainer, and solenoid drain valve.

c. The heat exchanger shall consist of coils fitted with fins (copper pipe, aluminum fins), distribution and header pipes (copper) and pipe connections to the pipeline system.

2. Coil
   a. The dry cooler coil shall have a floating coil design that prevents any contact of the refrigerant/fluid carrying tubes with the supporting frame allowing for thermal expansion and contraction of the tubes without risk of tube damage at the tube sheet.
   b. The coil shall use expanded support tubes to minimize flexing during installation.
   c. Coil shall be constructed of 0.47 inch diameter copper tubes.
   d. Fins shall be constructed of aluminum, full drawn collar with tubes expanded into collar.
   e. Coil tubes shall be connected to copper headers. Coils shall be pressure tested to 261 psig (18 bar) with dry air underwater and shipped with a 25 psig (1.7 bar) dry air holding charge.
   f. Coil shall be ETL listed.
3. Casing
   a. The dry cooler casing shall be robust, self-supporting construction of galvanized steel, powder coated with RAL 7035 (light grey). Within the casing, each fan chamber shall be separated by an internal baffle to prevent windmilling during off-cycle.
4. Fans
   a. Fan sets shall consist of a system utilizing external rotor motor with die cast aluminum sickle bladed impeller and fan guard. Impeller and rotor shall form one complete unit to ensure proper balancing.
   b. Fan sets shall be supplied with full bell mouth fan plate, optimized for highest efficiency.
   c. Wire fan guards shall be of welded construction, coated in a weather proof durable synthetic finish for maximum corrosion protection and in compliance with safety standard EN294.
   d. Fans shall be subject to balance quality Q6.3 according to VDI 2060.
5. Fan Motors
   a. Fan motors shall be Electronically Commutated (EC) with inherent ability to control fan speed without auxiliary components.
   b. Use of alternating current (AC) motors shall not be acceptable.
   c. Fan motors shall be furnished for operation on a 460 volt, 3 phase, 60 hertz power supply.
   d. Fan motor shall be maintenance free.
   e. Motors requiring periodic lubrication shall not be acceptable.
   f. Motors shall be sealed with a labyrinth seal impeding the ingress of splash water and include drain holes for condensation water drainage.
   g. Thermal contacts shall be integrated into the motor windings. Motors shall have protection class IP 54 and windings with thermal class F according to DIN EN 60 034-1.
6. Adiabatic Cooling System
   a. The indirect adiabatic cooling system will pre-cool the entering air stream prior to the finned coil heat transfer surface.
      1) Wetted pads shall be constructed of specially designed cellulose paper that is chemically treated to resist deterioration and bacterial growth.
      2) Güntner Hydro Management (GHM) controller shall be included to regulate water flow rate based on ambient conditions, fan speed and process

conditions. Ability to vary water flow rate is crucial to minimize water consumption. Systems that do not modulate water flow shall not be acceptable.

b. Controls shall determine requirement for water usage. If the external temperature and the fans' speed are above the set start value for the wetting, the wetting is activated. If the speed or the external temperature fall below the set value, the wetting is deactivated.
   1) The water distribution system shall include flow control valve, high pulse rate flow meter, strainer, piping, and solenoid drain valve. Recirculating systems with pump shall not be acceptable.

c. The water collection system shall be constructed of welded type 304 stainless steel and allow free drainage of excess water. Water basins or water collection devices that can allow for stagnant water shall not be acceptable.

d. Humidity and ambient temperature sensor shall be included.

C. Controls - Güntner Motor Management

1. Cooler shall be supplied with Güntner Motor Management (GMM) to create an intelligent fan motor system that optimizes operation of the cooler and simplifies maintenance. The controller adjusts fan motor speed based on temperature and regulating processes to provide reliability and information for the system. Systems that only allow steps of motors control or only motor cycling shall not be acceptable. GMM reduces sound emission due to no control-induced noise, especially in part-load operation.

2. GMM has various mode of operation for flexibility to meet demands of the system. Modes of operation include: Auto Internal for automatic control of fan speed based on factory supplied sensor; Auto External Analog for automatic control of fan speed based on externally supplied setpoint provided via analog input; Auto External BUS for automatic control of fan speed based on externally supplied setpoint provided via Modbus RTU communication/Modbus TCP/IP/ BACnet IP / BACnet MTSP; Slave External Analog for external control of fan speed sent via analog input; and Slave External BUS for external control of fan speed sent via Modbus RTU communication/Modbus TCP/IP/ BACnet IP / BACnet MTSP.
   a. Motors shall include Bypass mode. In the event of sensor fault, or loss of communication with control signal or fault in GMM, fan motors shall initiate emergency mode and run at a configurable fan speed. Factory default bypass mode fan speed shall be 100%.
   b. GMM shall include freeze protection mode and will oscillate fans in increasing amounts of torque in the event an obstruction such as snow or ice is detected. GMM shall take fan out of operation and indicate alarm in the event oscillation does not free fan from obstruction.
   c. Low Capacity Motor Management (LCMM) shall be available in order to provide more precise control during extreme low ambient or low load conditions. The GMM shall utilize LCMM to cycle fans while maintaining capacity and minimizing fan energy consumption.
   d. GMM shall utilize cleaning function to help remove dirt and debris from coil by running the fans in reverse at configurable intervals.
   e. Maintenance Run function shall be available to activate fan motors after configurable time of unit non-operation. Occasional use of fan motors is recommended during prolonged periods of non-operation.
   f. GMM shall include digital outputs for alarms (Fault/Warning), operational signal and threshold met. Additionally, GMM shall include analog output (0-10V signal) to indicate fan speed.

g. GMM shall include digital inputs for enabling of unit, night limit activation signal (which limits the fan speed and hence noise during configurable times) and secondary set point.
h. Modes of communication with GMM including Wi-Fi, Modbus RTU, BACnet IP or BACnet MSTP.

3. Provide factory mounted controls with Bacnet Connection in control panel.

D. Güntner Hydro Management
1. Cooler shall be supplied with Güntner Hydro Management (GHM) controller to regulate water flow required for Adiabatic Cooling System. Systems utilizing fixed flow rate for pre-cooling shall not be acceptable.
a. GHM shall include capability to operate in Water Savings Mode, Energy Savings Mode or Efficiency Mode, which is based on programmable dollar values for water and energy.
b. GHM shall monitor dry bulb temperature and humidity.
c. GHM shall regulate water flow rate based on ambient conditions and cooling load.
d. GHM shall initiate draining of water from Adiabatic Cooling System after 24 (configurable) hours of non-wetting or when ambient reaches 43°F (6°C). (configurable)
e. Modes of communication with GHM including Wi-Fi, Modbus RTU, BACnet IP or BACnet MSTP.
f. Water usage is recorded in the GHM
2. Controls shall be provided in NEMA 4 steel enclosure. Panel and included components shall adhere to UL508A.
3. Power distribution block and control transformer shall be included to allow for single point power connection. Motor safety protection for each fan motor shall be provided.
4. Non-fused disconnect, rated NEMA 4X, shall be included.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete bases, anchor-bolt sizes and locations, piping systems, and electrical systems to verify actual locations and sizes before evaporative refrigerant condenser installation.

B. Prior to start of installation, examine area and conditions to verify correct location for compliance with installation tolerances and other conditions affecting unit performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting:
1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Maintain manufacturer's recommended clearances for service and maintenance.

C. Loose Equipment: Install electrical components, devices, and accessories that are not factory mounted.

D. Provide complete installation of the adiabatic cooling system including but not limited to piping, piping accessories, mounting equipment, vibration isolation, controls all in accordance with the plans, specifications, and the manufacturer's requirements.

E. Provide all necessary wiring, conduit and devices required for a complete and operable system.

F. Maintain manufacturer’s recommended clearances for service and maintenance.

G. Install any electrical components, devices, and accessories that are not factory mounted.

3.3 PIPING CONNECTIONS

A. Install piping adjacent to evaporative refrigerant condensers to allow service and maintenance.

B. Install flexible pipe connectors at final connection of evaporative refrigerant condensers mounted on vibration isolators.

C. Run overflow, drain, and bleed lines to sanitary sewage system.

D. Domestic Water Piping: Comply with requirements in Section 221116 "Domestic Water Piping." Connect to water-level control with shutoff valve and union or flange at each connection.

E. Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Connect to supply and return basin-heater tappings with shutoff valve, strainer, control valve, and union or flange on supply connection and union or flange and balancing valve on return connection.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. 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. Locate nameplate where easily visible.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between control devices.

C. Connect control wiring according to Section 260523 "Control Voltage Electrical Power Cables."

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. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Evaporative adiabatic condenser will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

B. Obtain performance tables from manufacturer.

C. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Clean entire unit, including basins.
   3. Verify that accessories are properly installed.
   4. Check makeup water.
   5. Verify clearances for airflow and for evaporative refrigerant condenser servicing.
   6. Check for vibration isolation and structural support.
   7. Lubricate bearings on fans and shafts.
   8. Verify fan wheel rotation for correct direction and for vibration or binding. Correct vibration and binding problems.
   9. Adjust belts to proper alignment and tension.
   10. Operate variable-speed fans through entire operating range, and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.

11. Verify water level in basin. Fill to proper startup level. Check makeup water-level control and valve.
12. Start external-circuit circulating pumps.
13. Verify operation of evaporative refrigerant condenser basin, makeup line, automatic freeze protect dump, and controlling device. Replace defective and malfunctioning units.
14. Verify operation of basin heater and control thermostat. Replace defective and malfunctioning units.
15. Verify that evaporative condenser discharge is not recirculating into air intakes. Recommend corrective action.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing of evaporative refrigerant condensers.

E. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

3.8 ADJUSTING

A. Adjust water-level control for proper operating level.

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.

3.9 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain evaporative refrigerant condensers.

B. The following training shall be accomplished after the completion of each phase
1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
2. Provide a total of eight (8) hours of instruction at the site, during start-up.
3. Provide six (6) hours of instruction at the site after start-up
    a. Provide two (2) hours at three (3) months after start-up training
    b. Provide two (2) hour at six (6) months after start-up training.
    c. Provide two (2) hour at nine (9) months after start-up training

END OF SECTION 236333

SECTION 236423 WATER-COOLED, MODULAR CHILLERS

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. Design
   2. Performance Criteria
   3. Refrigerants
   4. Controls
   5. Installation

1.3 REFERENCES

A. ARI 550/590-2003

B. ANSI/ASHRAE 15

C. ASME Section VIII

D. NEC

E. UL

F. CSA

G. OSHA as adopted by each individual State.

1.4 DEFINITIONS

A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

B. DDC: Direct digital control.

C. EER: Energy efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

D. IPLV: Integrated Part-Load Value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.

E. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.

F. NPLV: Nonstandard Part-Load Value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.

1.5 ACTION SUBMITTALS

A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
1. Performance at AHRI standard conditions and at conditions indicated.
2. Performance at AHRI standard unloading conditions.
3. Minimum evaporator and condenser flow rate.
4. Refrigerant capacity of water chiller.
5. Oil capacity of water chiller.
6. Fluid capacity of evaporator.
7. Fluid capacity of condenser.
8. Characteristics of safety relief valves.
9. Minimum entering condenser-water temperature.
10. Performance at varying capacity with constant design condenser-water temperature. Repeat performance at varying capacity for different condenser-water temperatures from design to minimum in 5 deg F increments.
11. Force and moment capacity of each piping connection.

B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:
1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings:
1. Chiller dimensional drawings with elevation overview. Drawings to include required service clearances, location of all field installed piping and electrical connections.
2. Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
a. Structural supports.
b. Piping roughing-in requirements.
c. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
d. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.
3. Coordination drawings showing plan, section, and elevation views, drawn to ¼” =1’-0”.
4. Each view to show screened background with the following:

a. Column grids, beams, columns, and concrete housekeeping pads.
b. Room layout with walls, floors, and roofs, including each room name and number.
c. Equipment and products of other trades that are located in vicinity of chillers and part of final installation, such as lighting, fire suppression systems, and plumbing systems.

D. A summary of all auxiliary utility requirements for normal system operation required. Auxiliary utility requirements include: electrical, water, and air. Summary of auxiliary equipment shall include quantity and quality of each specific auxiliary utility required.

E. Chiller Control documentation to include: Chiller control hardware layout, wiring diagrams depicting factory installed wiring, field installed wiring with points of connection, and points of connection for BAS control/interface points.

F. Sequence of operation depicting overview of control logic used.

G. Manufacturer certified performance data at full load in addition to either IPLV or NPLV.

H. Certificates: For certification required in "Quality Assurance" Article.

I. Source quality-control test reports.

J. Startup service reports.

K. Sample Warranty: For special warranty.

L. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.

M. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 590 certification program.

B. Regulatory Requirements: Comply with the codes and standards as defined in Section 1.3 titled REFERENCES

C. Chiller is required to be run tested at manufacturer’s facility prior to shipment. Report available upon request.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

B. Package water chiller for export shipping.

C. Chiller modules shall be delivered to the job site completely assembled and charged with complete refrigerant charge.

D. Installing contractor to comply with the manufacturer's instructions for transporting, rigging, and assembly of modular chiller.

1.8 WARRANTY

A. Warranty Period: From date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of the chillers that fail in materials or workmanship within specified warranty period.
   1. Extended warranties include, but are not limited to, the following:
      a. Complete chiller including refrigerant and oil charge.
      b. Complete compressor and drive assembly including refrigerant and oil charge.
      c. Refrigerant and oil charge.
         1) Loss of refrigerant charge for any reason due to manufacturer product defect and product installation.
      d. Parts and labor.

C. The manufacturer's equipment warranty shall be for a period of (1) One year from date of equipment start up

D. The first-year warranty shall include: All parts, refrigerant, and limited labor.

PART 2 - PRODUCTS

2.1 Operating Conditions

A. Provide water-cooled liquid chiller with the capacity as scheduled on drawings.

B. Chiller shall be designed to operate using R- 513A Refrigerant.

C. Chiller shall be designed for parallel evaporator water flow.

D. Chiller shall be designed to operate using 460 volt, 3 phase, 60 Hz electrical power supply.

2.2 Water-Cooled Packaged Chiller

A. Approved manufacturer is MULTISTACK.

B. System Description: Chiller modules shall incorporate a two-stage centrifugal compressor with magnetic bearings and consist of a single 90-ton refrigerant circuit. The compressor shall utilize its integrated variable speed drive in conjunction with the compressor's inlet guide vanes to optimize the chillers part load efficiency. Each refrigerant circuit shall consist of an individual compressor, condenser, evaporator, electronic expansion valve, and control system. Each circuit shall be constructed to be independent of other circuits from a refrigeration and electrical stand-point. The chiller system must be able to produce chilled water even in the event of a failure of one or more refrigerant circuits.

C. General
   1. Chiller Modules shall be ETL listed in accordance with UL Standard 1995, CSA certified per Standard C22.2#236.
   2. Modules shall ship wired and charged with refrigerant. All modules shall be factory run tested prior to shipment on an AHRI certified or 3rd party verified test stand.
   3. Compressors, heat exchangers, piping and controls shall be mounted on a heavy gauge, powder coated steel frame. Electrical controls, and associated components for each module shall be mounted within that module.

D. Chilled and Condenser Water Mains: Each module shall include supply and return mains for both chilled and condenser water. Module piping will be rated for 150 psi working pressure. Cut grooved type end connections are provided for interconnection to eight-inch standard (8.625 inch outside diameter) piping with grooved type couplings. Water Mains shall be installed such that they are not above any power or control wiring so as to insure for safe operation in the event of condensation or minor piping leaks.

E. Evaporators and condensers: Each evaporator and condenser shall be tube in shell heat exchangers constructed with copper tubes in a carbon steel shell; built in accordance with Section VIII of the ASME code. Both the condenser and evaporator heat exchanger shall be mounted below the compressor, to eliminate the effect of migration of refrigerant to the cold evaporator with consequent liquid slugging on start-up. The evaporator shall include 3/4" closed cell foam insulation.

F. Total Access Design: Isolation valves shall be installed between the heat exchangers and water supply mains for heat exchanger isolation and removal without the requirement to remove a module or shut down the entire chiller allowing for total access to all serviceable components.

G. Chiller shall incorporate integral condenser and/or evaporator Nema 2 motorized butterfly valves for variable flow.

H. Electrical
   1. The two modules shall have a single point power connection (Hoffmann Style). The electrical connection type shall be a junction box.
   2. Mian Power Door interlock disconnect switch

I. Compressor:
   1. Unit shall have a direct drive oil-free two-stage semi-hermetic centrifugal compressor complete with an active / passive magnetic bearing system. Casing shall be constructed from aluminum and shall not weigh more than 300 lbs each. The electronic soft starters, compressor controls, inverter power electronics, bearing and motor control shall be fully integrated into the compressor and shall be digitally controlled. The magnetic bearing system must be fully protected in the case of a power outage with its own inbuilt power generation system.
   2. The impeller shall be statically and dynamically balanced. The compressor shall be vibration tested and not exceed a level of 0.14 IPS.
   3. The capacity control should primarily be achieved by varying the compressors operating speed and a movable inlet guide vane shall only be used in the case of a surge or choke condition arising during normal operation. The moveable inlet guide vane shall be of the electro-mechanical type.
   4. Bearing System: The compressor shall use an oil-free bearing system of the digitally controlled homo-polo magnetic bearing type. The bearings shall have a fully integrated

back up bearing system and shall have a self generating power system so that the bearings shall be able to stay levitated in the case of a power failure. No sump heater is to be required. The bearing system shall use no more than 500 watts of energy during its normal operation and it must also have an auto balance capability in the case of any external vibration or out of balance event occurring.

5. Prime Mover: A direct drive synchronous permanent magnet brushless DC motor of the hermetic type of sufficient size to efficiently fulfill compressor horsepower requirements. Motor shall be liquid refrigerant cooled with internal thermal overload protection devices embedded in the winding of each phase
6. Motor Starter: The main motor starter is to be fully integrated into the compressor and shall be of the soft-start type with a maximum starting current of 20% of the full load current of the compressor. It must be fully integrated with the motors variable speed control system and it must be factory tested during the run test of the unit.
7. Variable Frequency Drive: The chiller shall be equipped with a fully integrated Variable Frequency Drive (VFD) to automatically regulate compressor speed in response to cooling load and compressor pressure lift. The chiller control shall coordinate compressor speed and guide vane position to optimize chiller efficiency.
    a. Adigital regulator shall provide V/Hz control.
    b. The VFD shall have 110% continuous overload of continuous amp rating with no time limit, PWM (pulse width modulated) output, IGBT (insulated gate bipolar transistors) power technology, full power rating at 2kHz, DC bus inductor (choke), and wireless construction. The inverter unit shall be refrigerant cooled and shall be fully integrated into the compressor package.

J. Control System.
1. The unit shall have an industrial grade CPU with an ARM Cortex A-8 processor FlexSys Controller. All chiller and compressor I/O to be controlled via 10/100 Ethernet (2), RS-485 (2), and USB (2). Controller to have 19.5 inch TFT touch screen interface that can be disconnected and chillers still runs properly.
2. Controller to use natural progression control algorithms which properly define the compressors operating range to optimize loading, unloading, and control of multiple MagLev compressors. User shall operate chiller via HMI located on touch screen or remote web connection. All system parameters, compressor status, alarms, and faults, trend graphing, fault logging, bas communication window, log book, and control set points shall be viewable. Shall be able to fully commission and adjust all components on the chiller, including the compressors without an auxiliary computer or software.
3. The chiller controller shall include the necessary I/O for proper chiller operation including:
4. Hardware
    a. Dedicated EXV Output for each liquid level EXV and/or Economizer Valve Chiller LP Safety input
    b. Chiller HP Safety input Chilled Water Safety input Condenser Water Safety input
    c. E-Stop input
    d. Chilled Water Reset input
    e. Load Limit input
    f. Tower Setpoint output Chiller kW output
    g. Chiller Amps output
    h. Chiller Run Contact output
    i. Chiller Fault output
    j. Compressor Lockout Fault Status output
    k. Dedicated Compressor Enable output (no relay or paralleled signal)

l. Chilled Water In and Out Temperatures
m. Condenser Water In and Out Temperatures
n. Liquid Line Temperature(s)
o. Standard pump and tower control
p. Dedicated RS-485 communication to each compressor
q. Dedicated RS-232 communication to each compressor
r. Linux based operating system with embedded PC utilizing Windows.
s. DC Powered to ensure maximum resistance to EMI and RFI noise
t. Built in 2-port Ethernet Switch for easy integration to BAS interface and web control feature.
u. On board USB drives to support external peripheral devices including, keyboard, mouse, and printer
v. 19.5 “TFT display featuring 1024 X 768 Resolution. All hardware, including I/O is CE and UL Certified
w. All wiring utilizes spring capture technology to prevent loose connections or wires from falling out.
x. RS-485 communication at baud rate of 38,400 bps

5. Software
a. Controls shall have the capability of controlling different size and model compressors for maximum efficiency and turn down
b. HMI interface allows the user the following options: definable points list, tag names, and functions without special software. With this feature, end user can scale an all inputs and outputs, change what controls it, change the functionality, the name of it etc.
c. Chiller controller has the Danfoss Turbocor Compressor Software on board. This allows for no laptops for a service tech in additional to advanced remote troubleshooting.
d. Control System features easy to use web interface. This allows the user to do anything remotely that could be done in front of the chiller/
e. Over 200 data points are recorded in five (5) second intervals. Data can be analyzed with zoom feature. Data stored on separate 32 GB drive. Trend graph images can be exported. Trend graphs can be exported to csv files as well.
f. Advanced Fault Logging featuring calendar capability for ease of use. Data can be sorted by alarm type, time stamp, or compressor.
g. Color coded data. Green data means good, yellow means alarm, red means fault or off
h. Controller logs when user makes any type of change
i. Controller has onboard maintenance log to store system information Controller offers real time capacity and efficiency data
j. BAS Interfaces include:
1) BACNET MSTP
k. BAS interface dashboard shown on HMI. This allows the user to view what data is being written to the BAS system. Also shows if there is an error, last com, and how many times the data was sent or received.
l. Control system uses proprietary natural progression control algorithms to perform accurate energy balance on all systems for maximum system performance.
m. Control System features an optimum start function to ensure initial lift is always made. This prevents nuisance check valve flutter and compressor faults.

2.3 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.
   1. Single point power for the (2) modules, Connection is junction box with a wire whip for the modules.
   2. Main power door interlock disconnect
   3. 10kA SCCR

B. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.

C. House in a unit-mounted, NEMA 250, Type 1 enclosure with hinged access door with lock and key or padlock and key.

D. Wiring shall be numbered and color-coded to match wiring diagram.

E. Install factory wiring located outside of an enclosure in a metal raceway. Make terminal connections with not more than a 24-inch length of liquidtight conduit.

F. Field power interface shall be to circuit breaker. Minimum short circuit current rating (SCCR) according to UL 508 shall be as required by electrical power distribution system, but not less than 42,000A.

G. Each motor shall have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:
   1. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

H. Each motor shall have overcurrent protection.

I. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.

J. Phase Failure and Undervoltage: Solid-state sensing with adjustable settings.

K. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

L. Control Relays: Auxiliary and adjustable time-delay relays, or an integral component to water chiller microprocessor.

M. Indicate the following for water chiller electrical power supply:
   1. Current, phase to phase, for all three phases.
   2. Voltage, phase to phase and phase to neutral for all three phases.
   3. Three-phase real power (kilowatts).
   4. Three-phase reactive power (kilovolt amperes reactive).
   5. Power factor.
   6. Running log of total power versus time (kilowatt hours).
   7. Fault log, with time and date of each.

2.4 ACCESSORIES

A. Flow switches are typically thermal dispersion: All MagLev centrifugal chillers come with factory mounted and wired thermal dispersion switches with LED flow indication for flow protection. This feature allows MagLev centrifugal chillers the ability to provide low ΔP alarms, low ΔP faults, high ΔP alarms, and high ΔP faults. This ensures that the heat exchangers are protected against low flow or too much flow.

B. The chiller will have pressure information available through the controller, not external gauges. Each module is a single circuit.

C. Isolation is neoprene pads

2.5 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Chiller is required to be run tested at manufacturer’s facility prior to shipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.
   1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WATER CHILLER INSTALLATION

A. Coordinate sizes and locations of bases with actual equipment to be installed. Cast anchor-bolt inserts into concrete bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment to be installed.

C. Install water chillers on support structure indicated.

D. Equipment Mounting:
   1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

G. Chiller manufacturer's factory-trained service personnel shall charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

H. Install separate devices furnished by manufacturer and not factory installed.
   1. Chillers shipped in multiple major assemblies shall be field assembled by chiller manufacturer's factory-trained service personnel.

3.3 PIPING CONNECTIONS

A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to chillers, allow space for service and maintenance.

C. Evaporator Fluid Connections:
   1. Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage.
   2. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
   3. Make connections to water chiller with a flange.

D. Condenser Fluid Connections:

   1. Connect to condenser inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage.
   2. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
   3. Make connections to water chiller with a flange.

E. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15.

F. Connect each drain connection with a drain valve, full size of drain connection. Connect drain pipe to drain valve with union and extend drain pipe to terminate over floor drain.

G. Connect each chiller vent connection with an automatic or a manual vent, full size of vent connection.

H. Prior to connecting the chiller to the condenser and chilled water loop, the piping loops shall be flushed with a detergent and hot water (110-130° F) mixture to remove previously accumulated dirt and other organics. In old piping systems with heavy encrustation of inorganic materials, consult a water treatment specialist for proper passivation and/or removal of these contaminants.

I. During the flushing, a 30 mesh (max.) Y-strainers (or acceptable equivalent) shall be in place in the system piping and examined periodically as necessary to remove collected residue. The

flushing process shall take no less than 6 hours or until the strainers when examined after each flushing are clean. Old systems with heavy encrustation shall be flushed for a minimum of 24 hours and may take as long as 48 hours before the filters run clean. Detergent and acid concentrations shall be used in strict accordance with the respective chemical manufacturer's instructions. After flushing with the detergent and/or dilute acid concentrations the system loop shall be purged with clean water for at least one hour to ensure that all residual cleaning chemicals have been flushed out.

J. Prior to supplying water to the chiller the Water Treatment Specification shall be consulted for requirements regarding the water quality during chiller operation. The appropriate chiller manufacturer's service literature shall be available to the operator and/or service contractor and consulted for guidelines concerning preventative maintenance and off-season shutdown procedures.

3.4 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 0.5 inch high. Locate nameplate where easily visible.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between chillers and other equipment to interlock operation as required for a complete and functioning system.

C. Connect control wiring between chiller control interface and DDC System for remote monitoring and control of chillers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Install nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 0.5 inch high.

3.6 WATER TREATMENT REQUIREMENTS

A. Supply water for both the chilled water and condenser water circuits shall be analyzed and treated by a professional water treatment specialist who is familiar with the operating conditions and materials of construction specified for the chiller's heat exchangers, headers and associated piping. Cycles of concentration shall be controlled such that recirculated water quality for

modular chillers using 316 stainless steel brazed plate heat exchangers and carbon steel headers is maintained within the following parameters:

1.	pH	Greater than 7 and less than 9
2.	Total Dissolved Solids (TDS)	Less than 1000 ppm
3.	Hardness as CaCO3	30 to 500 ppm
4.	Alkalinity as Ca CO3	30 to 500 ppm
5.	Chlorides	Less than 200 ppm
6.	Sulfates	Less than 200 ppm

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Technician to provide complete start-up supervision. Factory Authorized Service Technician shall also be responsible for assembly of the chillers cabinetry package and electrical bus bar system. After start-up a Manufacturer's Representative shall provide a minimum of 2-hours of operator training to the owner's designated representative.

C. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

D. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled- and condenser-water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

E. Inspect field-assembled components; equipment installation; and piping, controls, and electrical connections for proper assembly, installation, and connection.

F. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.

G. Prepare a written startup report that records results of tests and inspections.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. Video record the training sessions and provide electronic copy to Owner.
   1. Instructor shall be factory trained and certified.
   2. Provide not less than eight (8) hours of training after the initial stare up start operation. Training.
      a. Provide two (2) hours of instruction at the start-up
      b. Provide two (2) hours at three (3) months after start-up training
      c. Provide two (2) hour at six (6) months after start-up training.
      d. Provide two (2) hour at nine (9) months after start-up training
      e.
   3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant
   4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
   5. Obtain Owner sign-off that training is complete.
   6. Owner training shall be held at Project site.

END OF SECTION 236423.16

SECTION 237223.29 - PACKAGED, FIXED PLATE ENERGY RECOVERY 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 RELATED SECTIONS

A. Section 234100 - Particulate Air Filtration

1.3 SUMMARY

A. Section Includes:
   1. This section includes Air-to-Air Energy Recovery Ventilators for indoor and outdoor installation.
   2. Within this document, these units may be referred to as Energy Recovery Ventilator (ERV) for brevity.
   3. Fixed-plate, sensible heat exchangers in packaged indoor and outdoor, energy-recovery units.

B. Related Requirements:
   1. Drawing and general provisions of the contract, including General Requirements Division 01, Division 23, Division 23 Specifications Sections, and common work requirements for HVAC apply to work specified in this section.
   2. Section 230900: Controls and Instrumentation
   3. Section 230548 - Wind Restraints for HVAC Components. Wind Restraint and mounting requirements

1.4 PRODUCT SPECIFICATION

A. Energy Recovery Ventilators shall be a packaged unit and shall transfer both heat and humidity using static plate core technology.

1.5 ACTION SUBMITTALS

A. Product data: For each type or model of Energy Recovery Ventilator, include the following:
   1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
   2. 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.

3. Unit performance data for both Supply Air and Exhaust Air, with system operating conditions indicated Enthalpy plate performance data for both summer and winter operation.
4. Motor ratings and unit electrical characteristics.
5. Wiring Diagrams: For power, signal, and control wiring.
6. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.
7. Estimated gross weight of each installed unit.
8. Filter types, quantities, and sizes
9. Installation, Operating and Maintenance manual (IOM) for each model.
10. Wind Restraints for HVAC Components. Wind Restraint and mounting requirements per Section 230548.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, roof plans, elevations, and other details, drawn to scale. and coordinated with each other, using input from installers of items involved.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For energy-recovery equipment to include in maintenance manuals.

1.8 MAINTENANCE MATERIAL

A. Furnish extra materials that match products installed. Package with protective covering for storage and identify with labels describing contents.
1. Filters:
a. One set(s) of each type of filter specified per ERV.
2. Fan Belts:
a. One set(s) of belts for each belt-driven fan in energy recovery units per ERV.

1.9 QUALITY ASSURANCE

A. Source Limitations: Obtain Air-to-Air Energy Recovery Ventilator with all appurtenant components or accessories from a single manufacturer.

B. For the actual fabrication, installation, and testing of work under this section, use only thoroughly trained and experienced workers completely familiar with the items required and with the manufacturer's current recommended methods of installation.

C. The ERV core shall be warranted to be free of manufacturing defects and to retain its functional characteristics, under circumstances of normal use, for a period of ten (10) years from the date of purchase. The balance-of-unit shall be warranted to be free of manufacturing defects and to retain its functional characteristics, under circumstances of normal use, for a period of two (2) years from the date of installation.

D. Manufacturer shall be able to provide evidence of independent testing of the core by Underwriters Laboratory (UL), verifying a maximum flame spread index (FSI) of 25 and a maximum smoke developed index (SDI) of 50 thereby meeting NFPA90A and NFPA 90B requirements for materials in a compartment handling air intended for circulation through a duct system. The method of test shall be UL Standard 723.

E. Certifications:
   1. The energy recovery cores used in these products shall be third party Certified by AHRI under its Standard 1060 for Energy Recovery Ventilators. AHRI published certifications shall confirm manufacturer's published performance for airflow, static pressure, temperature and total effectiveness, purge air (OACF) and exhaust air leakage (EATR). Products that are not currently AHRI certified will not be accepted. OACF shall be no more than 1.02 and EATR shall be at 0% against balanced airflow.
   2. Entire unit shall be listed under UL 1812 Standard for Ducted Air to Air Heat Exchangers and comply with CSA Standard 22.2.

F. Every unit to be factory tested prior to shipping: Motor Dielectric Voltage-Withstand Bench Test, Unit Dielectric Voltage-Withstand Test, Continuity of Internal Control Circuits Test, Unit Amperage Test

1.10 COORDINATION

A. Coordinate sizes and locations of building openings and duct connections with actual equipment provided. Provide shop Drawings of ductwork from ERV to connection points with AHU return and exterior walls.

B. Coordinate size and location of all building penetrations required for installation of each Energy Recovery Ventilator and associated electrical systems.

C. Coordinate sequencing of construction for associated plumbing, HVAC, electrical supply.

D. Coordinate sizes and locations of roof curbs, equipment supports, roof penetrations, and concrete pads with actual equipment provided.

1.11 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, outdoor, fixed-plate, energy-recovery units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Packaged Energy-Recovery Units: One year(s) from date of beneficial occupancy depending on the construction phase when that specific unit is placed in service.
   2. Warranty Period for Fixed-Plate Heat Exchangers: Five years from date of beneficial occupancy depending on the construction phase when that specific unit is placed in service.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

B. ASHRAE Compliance:
1. Applicable requirements in ASHRAE 62.1.
2. Capacity ratings for fixed-plate energy-recovery units shall comply with ASHRAE 84.

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. UL Compliance:
1. Packaged heat-recovery ventilators shall comply with requirements in UL 1815 or UL 1812.

E. Comply with ASTM E84 or UL 723.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by NRTL, and marked for intended location and application.

G. AHRI Compliance: Capacity ratings for air-to-air energy-recovery equipment certified as complying with AHRI 1060

H. Fan Performance Rating: Comply with AMCA 211, and label fans with AMCA-certified rating seal. Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210 and ASHRAE 51.

I. Fan Sound Ratings: Comply with AMCA 301 or AHRI 260.

J. Section 230548 - Wind Restraints for HVAC Components. Wind Restraint and mounting requirements
1. Wind restraint Performance.

K. Comply with 2020 NYSECC C403.7.4 for Energy Recovery Ventilation System Requirements.

2.2 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with specifications contained within this document, manufacturers offering products that may be incorporated into the work include, but are not limited to:
1. RenewAire (BASIS OF DESIGN)
2. Greenheck Fan Corporation.
3. Venmar CES Inc.

B. Manufacturer should be in business for minimum 10 years manufacturing energy recovery ventilators.

2.3 MANUFACTURED UNITS

A. Air-to-Air Energy Recovery Ventilators shall be fully assembled at the factory and consist of a fixed-plate cross-flow heat exchanger with no moving parts, an insulated double wall G90 galvanized painted 20-gauge steel cabinet, outdoor air hood with bird screen, (for outdoor units) motorized outside air intake damper, filter assemblies for both intake and exhaust air, enthalpy core, supply air blower assembly, motorized return air damper, exhaust air hood, exhaust air blower assembly and electrical control box with all specified components and internal accessories factory installed and tested and prepared for single-point high voltage connection. Entire unit with the exception of field-installed components shall be assembled and test operated at the factory.

2.4 ENERGY RECOVERY VENTILATOR – OUTDOOR ROOFTOP

A. Performance
   1. Energy Transfer: The ERV shall be capable of transferring both sensible and latent energy between airstreams. Latent energy transfer shall be accomplished by direct water vapor transfer from one airstream to the other, without exposing transfer media in succeeding cycles directly to the exhaust air and then to the fresh air.
   2. Passive Frost Control: The ERV core shall perform without condensing or frosting under normal operating conditions (defined as outside temperatures above -10°F and inside relative humidity below 40%). Occasional more extreme conditions shall not affect the usual function, performance or durability of the core.
   3. Design Conditions:
      a. Summer outdoor design conditions 88.7F DB / 73.2F WB
      b. Winter outdoor design conditions 2.9F DB / -0.4F WB

B. Control center / connections: Energy Recovery Ventilator shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections to the non-fused disconnect.

C. Positive Air stream Separation
   1. Exhaust and fresh airstreams shall at all times travel in separate passages, and airstreams shall not mix. The exhaust air transfer ratio (EATR) of the energy recovery component shall be ARI-1060 certified as 0% at balanced pressure. No metal separators or metal core material shall be acceptable.

D. Laminar Flow
   1. Airflow through the energy recovery core shall be laminar, avoiding deposition of particulates on the interior of the exchange plate material.

E. Isolation Dampers
   1. Motorized Isolation Damper(s): Return Air and Outside Air motorized damper(s) of an AMCA Class I low leakage type shall be factory installed.
   2. Isolation dampers shall be AMCA-certified Class 1 or Class 1A to demonstrate leakage of less than 4 SCFM/ft2 at 1.0” H2O static pressure difference (forward flow), thus satisfying requirements of ASHRAE 90.1-2007 Section 6.4.3.4.3.
   3. Dampers shall be equipped with replaceable EPDM blade seals and stainless-steel compression jamb seals.

4. Dampers shall be controlled to be fully open before blowers begin operation, and to be fully closed whenever ventilation is not called for.

F. Air-to-Air Energy Recovery Ventilators shall be fully assembled at the factory and consist of a fixed-plate cross-flow heat exchanger with no moving parts, an insulated double wall G90 galvanized painted 20-gauge steel cabinet, outdoor air hood with bird screen, motorized outside air intake damper, filter assemblies for both intake and exhaust air, enthalpy core, supply air blower assembly, motorized exhaust air damper, exhaust air hood, exhaust air blower assembly and electrical control box with all specified components and internal accessories factory installed and tested and prepared for single-point high voltage connection. Entire unit with the exception of field-installed components shall be assembled and test operated at the factory

G. Construction
1. The energy recovery core shall be of static plate, cross-flow construction, with no moving parts.
2. Fixed-Plate, Sensible Heat Exchanger:
   a. Casing: Aluminum.
   b. Drain Pan: Same material as casing, with drain connections on exhaust and supply side.
   c. Comply with requirements in ASHRAE 62.1.
   d. Plates: Evenly spaced, sealed, and arranged for counter-flow.
   e. Plate Material: Polymer meeting UL flame spread requirements.
   f. Class I low leakage motorized isolation dampers for outside air and return air.
3. The unit cabinet shall be constructed of galvanized, 20-gauge steel, with lapped corners and zinc-plated screw fasteners. The unit roof shall have watertight standing seam joints and shall overlap wall panels and doors to positively shed water.
4. All unit cabinet panels shall be insulated to a minimum R-value of 4.3 (hr·ft2·°F/BTU).
5. (Double Wall) All compartments shall be fully lined with 24-gauge minimum G90 galvanized steel.
6. All unit cabinet panels shall display deflection no greater than L/120 when unit is depressurized to -2.0” relative to ambient.
7. Unit shall be provided on a 10-gauge base rail for with provisions for movement on site by fork.
8. Unit shall be provided with minimum of (4) lifting points suitable for placement of the unit on a roof curb by crane or other lifting means. Rigging information including weights at lifting points and spreader bar requirements shall be provided.
9. Flange components shall be provided suitable for connection of ductwork.
10. Weatherhoods shall be screened to exclude birds and animals. Inlet weatherhoods shall be equipped with rain excluded baffles
11. The exhaust and fresh air streams shall both be protected by MERV 8 rated, 2-inch pleated, disposable filters positioned before the energy recovery core.
12. The unit shall have single-point power connection.
13. Motors shall be NEMA-Premium efficiency, Inverter Duty, Totally Enclosed Fan-Cooled (TEFC), with inverterrated construction.
14. Motors shall be controlled by individual Variable Frequency Drives, each of which shall be additionally protected by fuses contained in the unit electrical enclosure.
15. The keypads of the Variable Frequency Drives shall be accessible by means of removable access panels while the unit is running, without exposure of internal wiring or connections. Air leakage through the access panels while open shall not exceed 60SCFM under any operating conditions.

16. Unit compartments containing high voltage shall be accessible through a door which cannot be opened until the unit's primary load switch is turned off to disconnect all power downstream of that switch.
17. Static pressure measurement ports shall be provided along with charts such that both airflows across the energy recovery core can be measured during unit operation, in energy recovery or bypass modes, with an uncertainty less than 10%.
18. Internal operating logic shall be provided by stand-alone relays, temperature controllers, and enthalpy controllers.
19. The unit electrical box shall include a factory installed, non-fused disconnect switch and a 24 VAC, Class II transformer/relay package.
20. Blowers type shall be quiet running direct drive and forward curved.
21. Blowers shall be premium efficiency, EISA compliant for energy recovery efficiency. The blower motors shall be totally enclosed (TEFC) and shall be supplied with factory installed VFDs.

H. Accessories
1. Provide units with Air Flow Stations for the supply and exhaust fans. Air Flow Stations shall connect to the Building Management System.
2. Provide factory installed filter monitors for each airstream.
3. Provide double wall construction with 24-gauge galvanized steel liner.
4. Units are available single or three phase at a full range of operating voltages. See project schedule.
5. Provide motor horsepower as specified in project schedule.
6. Provide with fused disconnect.
7. Provide factory installed disconnect fuses.
8. Provide factory installed Variable Frequency Drives allowing either preset or variable speed operation with appropriate 0–10-volt DC or DDC control signal.
9. Provide factory installed motorized isolation dampers for both air streams. The insulated dampers shall be of a low leakage design and shall not restrict the airstream, reducing airflow, in any way. The dampers shall be opened with a motor actuator powered by the standard unit transformer package and have a spring return for low off-position power consumption.
10. Provide MERV-8 filters for final installation after construction phase.
    a. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
    b. Filters Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
    c. Provide 2" minimum MERV 8 filters with factory mounted filter alarms in both airstreams connected to the BMS System.
    d. UL Compliance: Comply with UL 900.
    e. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
    f. Filter-Mounting Frames: Arranged with access doors or panels on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
11. Roof Curb: Galvanized steel construction; complying with NRCA standards. Provide a 24" tall one piece, continuously welded, 12 ga. galvanized curb which shall have a 3" tall collar to accept the heat recovery unit. Walls of curb shall be lined with 1-1/2" of rigid insulation to prevent condensation and shall be internally reinforced to support imposed loads. Provide with lifting rings or temporary supports as required for safe handling and rigging.
12. Provide high wind tie-down kit.
13. Provide with BACnet MSTP/IP connection.

2.5 CONTROLS

A. Control Panel: Solid-state, programmable, enhanced, premium microprocessor-based control unit for unit mounting. Integrate to BACnet, , as specified in Section 230923 "Direct Digital Control (DDC) System for HVAC".

B. Frost Control: Low-temperature thermostat deenergizes supply air fan.

C. Dry-bulb temperature sensor.

D. Dirty filter switch.

E. Low-Voltage Transformer: Integral transformer to provide control voltage to unit from primary incoming electrical service.

2.6 UNIT CONTROLS

A. Fan control: Onboard VFD or speed controller both airstreams.

B. Sensors: Dirty filter monitor for both airstreams.

C. Factory-installed microprocessor controller and sensors, Premium ERV controls that:
1. Comply with requirements in Division 23 Section "Sequence of Operations for HVAC Controls"
2. Has factory-installed hardware and software to enable the building automation interface via BACnet to monitor, control, and display status and alarms
3. The microprocessor controller shall be capable of operating at temperatures between -20F to 160F
4. The microprocessor controller shall be a DIN rail mounting type
5. Factory-installed microprocessor controller shall come with backlit display that allows menu-driven display for navigation and control of unit
6. The microprocessor controller shall have the ability to communicate with the BMS via Modbus RTU/TCP and BACnet MSTP/IP
7. The microprocessor controller shall have integrated ethernet interface and a web server for displaying unit parameters
8. The microprocessor shall have near field communication (NFC) capability for android devices
9. The microprocessor controller shall have an internal programmable time clock that will allow the user to add different occupancy schedules and add holidays
10. The microprocessor control shall be capable of integral diagnostics
11. The microprocessor control shall be capable of IP or SI unit display
12. The microprocessor controller shall have a battery powered clock
13. The microprocessor controller shall at a minimum offer the ability for three modes of determining occupancy: a dry contact, the internal time clock or the BMS
14. BMS interface to allow for remote monitoring and adjustment of parameters, allowing ease of control access without going outdoors or into the mechanical room if desired by the user
15. The microprocessor controller shall have at a minimum (10) universal inputs/outputs (AI, DI, AO) and have (6) six relay outputs (DO)
16. The microprocessor controller shall have an integrated fieldbus port

17. The microprocessor controller shall have the capability for I/O expansion
18. The microprocessor controller shall have a micro USB port to load the application program, the unit parameters, saving logs, etc.
19. The sensors that will be required for control are:
    a. (2) Temperature sensor for fresh air and exhaust air
    b. (2) Temperature and humidity sensor for outside air, return air
    c. (2) Differential pressure sensors for filter alarms
    d. (2) Differential pressure sensors for measuring pressure drop across energy recovery core and for determining airflow in both airstreams
    e. (2) Adjustable current switches
    f. Field-installed duct CO2 sensor
20. The microprocessor controller shall have the capability to monitor the unit conditions for alarm conditions. Upon detecting an alarm, the microprocessor controller shall have the capability to record the alarm description, time, date, available temperatures, and unit status for user review. A digital output shall be reserved for remote alarm indication. Alarms to be also communicated via BMS as applicable. Provide the following alarm functions:
    a. Outside air temperature sensor alarm
    b. Outside air humidity sensor alarm
    c. Return air temperature sensor alarm
    d. Return air humidity sensor alarm
    e. Fresh air sensor alarm
    f. Exhaust air sensor alarm
    g. Dirty filter alarm
    h. Supply and exhaust air proving alarm
    i. Outside airflow sensor alarm
    j. Exhaust airflow sensor alarm
    k. Duct static pressure sensor alarm
    l. CO2 sensor alarm
    m. Airflow out of range alarm
21. Display the following on the face of microprocessor controller:
    a. Unit on
    b. Outdoor air temperature
    c. Outdoor air humidity
    d. Return air temperature
    e. Return air humidity
    f. Supply air temperature
    g. Airflows in both airstreams
    h. Unit on/off
    i. Fan on/off
    j. Damper status
    k. Alarm digital display
22. Air Flow Stations for the supply and exhaust fans shall connect to the Building Management System.
23. The microprocessor controller shall have factory pre-programmed multiple operating sequences for control of the ERV. Factory default settings shall be fully adjustable in the field. Available factory pre-programmed sequences on operations are:

2.7 SEQUENCE OF OPERATIONS

A. This is the internal sequence of the ERV. Refer to the control drawings to review the overall coordination of the ERV with the Air Handler Unit s(AHU)

B. DDC CONTROLLER:
1. Controller with integral LCD readout for changing set points and monitoring unit operation.
2. Provided with required sensors and programming.
3. Factory programmed, mounted, and tested.
4. Integral USB and Ethernet ports for updating programs and retrieving log files.
5. BMS INTERFACE:

C. BACnet MS/TP
1. BACnet IP

D. POWER UP:
1. When the unit main disconnect is closed a delay of 10 seconds (adjustable) occurs for the controller to come online.

E. ERV UNIT START COMMAND:
1. An input signal is required to enable the unit operation. The unit will be commanded on by:
a. Digital input
b. BMS command
c. Internal time clock
d. Enable via controller display
2. All types of input that are enabled must be true before the unit will start.
a. The exhaust fan starts after a 3 second delay (adjustable). The exhaust fan will not start until the damper actuator end switch closes.
b. The supply fan starts after a 6 second delay (adjustable). The supply fan will not start until the damper actuator end switch closes.
c. The supply fan, exhaust fan, (heating) are controlled based on the chosen unit operating modes and air conditions.

F. ERV UNIT STOP COMMAND (OR DE-ENERGIZED):
1. The unit can then be commanded off by:
a. Digital input
b. BMS command]
2. Supply fan and exhaust fan are de-energized.
3. All dampers are unpowered and spring return to their default position after a 10 second delay (adjustable).

G. SUPPLY FAN OPERATION:
1. The supply fan will operate at a constant flow rate. For rooftop units supply fan shall be OFF during economizer cycle where AHUs have direct access to OA.
2. VFD shall modulate based on the BMS input
3. The unit will attempt to start the supply fan when the supply fan delay timer expires. When the supply fan starts the supply fan adjustable current switch should close and remain closed until the fan is turned off.

H. SUPPLY FAN STATUS:
1. Once the supply fan current switch closes heating operation is allowed. After a delay of 90 seconds (adjustable) from supply fan start signal, if the supply fan current switch is still open the supply fan alarm should be set to true and heating operation shall be prohibited. The supply fan status shall be set to true only when the supply fan output is on and supply fan current switch is closed. The supply fan status shall be false in all other circumstances.

I. FIXED FAN SPEED:
1. The analog voltage command to the supply fan VFD can be set from the unit controller display or by the BMS. The adjustable range of 0% to 100% correspond to the minimum and maximum fan operating speed. This supply fan operation mode can be used to field balance the supply air flow rate.

J. SUPPLY AIR FLOW CONTROL:
1. The controller will adjust the supply fan VFD command to maintain the supply air flow rate at a set point. The supply air flow rate set point is entered and adjusted from the unit controller display or provided by the BMS. The minimum and maximum values for supply air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured supply air flow to the air flow rate set point and adjust the fan speed. If the measured supply air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) a supply air flow rate alarm will be set to true. This supply fan operation mode can be used to provide a constant supply air flow rate as the unit filters become loaded.

K. EXHAUST FAN OPERATION:
1. The exhaust fan will operate at a constant flow rate, except to match AHU economizer operations.
2. The unit will attempt to start the exhaust fan when the exhaust fan delay timer expires. When the exhaust fan starts the exhaust fan adjustable current switch should close and remain closed until the fan is turned off.

L. EXHAUST FAN STATUS:
1. After a delay of 90 seconds (adjustable) from exhaust fan start signal, if exhaust fan current switch is still open the exhaust fan alarm should be set to true. The exhaust fan status shall be set to true only when the exhaust fan output is on and exhaust fan current switch is closed. The exhaust fan status shall be false in all other circumstances.

M. FIXED FAN SPEED:
1. The analog voltage command to the exhaust fan VFD can be set from the unit controller display or provided by the BMS. The adjustable range of 0% to 100% correspond to the minimum and maximum fan operating speed (0 VDC minimum to 10 VDC maximum, adjustable). This exhaust fan operation mode can be used to field balance the exhaust air flow rate.

N. EXHAUST AIR FLOW:
1. The controller will adjust the exhaust fan VFD command to maintain the exhaust air flow rate at a set point. The exhaust air flow rate set point is entered and adjusted from the unit controller display or provided by the BMS. The minimum and maximum values for the exhaust air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured exhaust air flow to the air flow rate set point

and adjust the fan speed. If the measured exhaust air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) an exhaust air flow rate alarm will be set to true. This exhaust fan operation mode can be used to provide a constant exhaust air flow rate as the unit filters become loaded.

O. AIR FLOW STATIONS
1. The controller will monitor the air flow stations output. The air flow from the unit controller shall be display on the controller and provided by the BMS.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prior to start of installation, examine area and conditions to verify correct location for compliance with installation tolerances and other conditions affecting unit performance. See unit IOM.

B. Examine roughing-in of plumbing, electrical and HVAC services to verify actual location and compliance with unit requirements. See unit IOM.

C. Proceed with installation only after all unsatisfactory conditions have been corrected

D. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

E. Examine casing insulation materials and filter media before packaged, outdoor, fixed-plate, energy-recovery unit installation. Replace insulation materials and filter media that are wet, moisture damaged, or mold damaged.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Installation shall be accomplished in accordance with these written specifications, project drawings, manufacturer's installation instructions as documented in manufacturer's IOM, Best Practices and all applicable building codes.

B. Install units with clearances for service and maintenance.

C. Use proper rigging, including spreader bars, for safe lifting and placement.

D. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

E. Install insulation over the decking inside the curb. Refer to drawings for insulation thickness requirements.

F. Roof Curb: Install on roof structure, level and secure, according to The NRCA "Roofing and Waterproofing Manual - Volume 4: Construction Details - Low-Slope Roofing," Illustration

"Raised Curb Detail for Rooftop Air Handling Units and Ducts" or ARI Guideline B. Install air-to-air energy recovery equipment on curbs and coordinate roof penetrations and flashing with roofing work shown on Architectural drawings Secure air-to-air energy recovery equipment to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

3.3 CONNECTIONS

A. In all cases, industry Best Practices shall be incorporated. Connections are to be made subject to the installation requirements shown above.

B. Comply with requirements for ductwork specified in Division 23 Section "Air Duct Accessories." Drawings indicate general arrangement of fittings, and specialties.

C. Comply with requirements for ductwork specified in Division 23 Section "Metal Ducts."

D. Electrical Connections: Comply with applicable requirements in Division 26 Sections.

E. Install electrical devices furnished with units but not factory mounted.

3.4 INSTALLATION OF PACKAGED, OUTDOOR, FIXED-PLATE, ENERGY-RECOVERY UNITS

A. Install packaged, outdoor, fixed-plate, energy-recovery units, so supply and exhaust airstreams flow in opposite directions.
   1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to interior components.
   2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
   3. Access doors and panels are specified in Section 233300 "Air Duct Accessories."

B. Equipment Mounting:
   1. Install roof-mounted packaged, outdoor, fixed-plate, energy-recovery units on manufacturer's-recommended-height equipment roof curbs.

C. Install units with clearances for service and maintenance.

D. Do not operate equipment fans until temporary or permanent filters are in place. Replace temporary filters used during construction and testing with new, clean filters prior to final inspection.

E. Unit Location and Placement
   1. Locate and orient unit to provide the shortest and most straight duct connections. Provide service clearances as indicated on the plans. Locate units distant from sound critical occupancies.
   2. Install a structurally sound, weathertight, level and properly insulated roof curb with nailers, curb gasket and tie-downs to meet local wind load requirements.
   3. Insure roof decking penetrations inside curb are properly positioned and sized for ducts. Seal all penetrations and gaps between ducts and decking with appropriate fire, weather and acoustic sealant system.

4. Install fiberglass batt insulation over the decking inside the curb. Insulation thickness to be determined by local thermal requirements.
5. Use proper rigging, including spreader bars, for safe lifting and placement.

F. Vibration Isolation
1. Provide 5/8” thick rubber vibration pads between ERV and curb.
2. Provide flexible duct connections at unit duct flanges.

G. Duct Design
1. Ductwork shall be designed, constructed, supported and sealed in accordance with SMACNA HVAC Duct Construction Standards and pressure classifications.
2. Ductwork shall be installed to the curb duct adaptors before unit is set in place.
3. Both the return and the supply ducts shall be thermally insulated at levels appropriate to the local climate from the unit through the curb and continuous until at least the first elbow or tee. A continuous vapor barrier shall also be provided on warm surface of the insulation.
4. Comply with requirements for ductwork in accordance with Section 233113 "Metal Ducts."
5. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
6. Isolation Dampers: Install isolation dampers in accordance with Section 230923.12 "Control Dampers."

3.5 TEST AND BALANCING

A. Test and Balancing may not begin until 100% of the installation is complete and fully functional.

B. Follow National Comfort Institute (NCI) air test and balance procedures specific to Heat Recovery Ventilator Balancing Procedure including standard reports to the owner’s representative.

3.6 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

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.

3.7 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."

3.8 ADJUSTING

A. Adjust moving parts to function smoothly and lubricate as recommended by manufacturer.

B. Adjust initial temperature and humidity setpoints.

C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.9 FIELD QUALITY CONTROL

A. Contractor to inspect field assembled components and equipment installation, to include electrical and piping connections. Report results to Architect/Engineer in writing. Inspection must include a complete startup checklist to include (as a minimum) the following: Completed Start-Up Checklists as found in manufacturer's IOM. Insert any other requirements here.

B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

C. 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.

D. Tests and Inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Adjust seals and purge.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   4. Set initial temperature and humidity set points.
   5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

E. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.10 STARTUP SERVICE

A. Engage factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks in accordance with manufacturer's written instructions.

B. Contractor to perform startup service. Clean entire unit, comb coil fins as necessary, and install clean filters. Measure and record electrical values for voltage and amperage. Refer to Division 23 "Testing, Adjusting and Balancing" and comply with provisions therein.

C. Start-up shall include ERV operation with the related AHU running in normal and economizer mode.

3.11 DEMONSTRATION AND TRAINING

A. Engage factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy-recovery units.

B. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of eight (8) hours of instruction at the site, during start-up.
   3. Provide six (6) hours of instruction at the site after start-up
      a. Provide two (2) hours at three (3) months after start-up training
      b. Provide two (2) hour at six (6) months after start-up training.
      c. Provide two (2) hour at nine (9) months after start-up training

END OF SECTION 237223.29

SECTION 237313 – INDOOR, CUSTOM AIR-HANDLING UNITS

PART 1 - 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 of the work includes the design, fabrication, testing, cleaning and packaging, shipment, final assembly and installation of custom built-up air handling units.

B. Provide all labor, materials, equipment, and services to perform all operations required for the complete installation as shown on the Contract Documents.

C. Related work specified elsewhere:
1. Section 23 – Motors
2. Section 23 – Adjusting and Balancing
3. Section 23 – Building Automation and Controls
4. Section 23 – Air Filters
5. Section 23 - Coils

D. Section includes indoor, custom air-handling units with capacities, characteristics and configurations indicated on Drawings.
1. SMACNA leakage class rating of 5.0
2. Maximum panel deflection shall not exceed L/200 at design total static pressure
3. Minimum R-12 insulation value for walls, ceilings, and flooring
4. 2-1/2” Double wall thermal-break panels (walls, Floor, Roof)
5. 0.040" aluminum outer wall, 0.040" aluminum inner wall
6. 2 lb/ft3 polyurethane foam injected insulation in the walls and ceiling
7. Designed for indoor installation.
8. Maximum weight as per schedule shall not be exceeded.
9. Mechanical Contractor shall be responsible for any schedule or specification deviation in performance, specifics or construction.
10. Fan motors shall have individual controllers.
11. Perforated liner is to be provided in the fan sections for additional sound attenuation.
12. Controls are to be provided by others and mounted/wired in conduit.
13. The unit shall ship completely knocked down and shall not be assembled prior to shipment. All components and crates shall fit through a 7’H x 6’W door. All silicone, gasketing, flashing and fasteners required to assemble the unit shall be provided and shipped with the unit components.

E. AHU shall be fully assembled on site and all electrical work shall be field wire by the Mechanical Contractor. Mechanical Contractor shall obtain the services of a License Electrical Contractor to wire the units in the field as it is being erected.

1.3 MANUFACTURER'S (EQUIPMENT SUPPLIER'S) GENERAL REQUIREMENTS

A. Design Equipment
   1. Basis Of Design Equipment: Air Enterprises
   2. Acceptable Makes: Environmental Air Systems, Buffalo Air Handling.
   3. Alternate manufactures must receive written permission to bid via Addendum 15 days prior to the bid and follow the Alternate procedure outlined in Specification DIVISION 01
   4. The unit manufacturer shall have been manufacturing custom built-up air handling units for a minimum of 20 years.

B. It is the intent of these specifications and referenced specification sections to provide the minimum design and performance parameters without being proprietary toward a specific equipment supplier. It is the responsibility of the listed acceptable equipment suppliers to meet the basic intent of the specifications and drawings. The overall "box" size of Air Handling Units as shown on Drawings shall not be deviated from. It is not the option of the equipment supplier to increase or decrease the physical size of the equipment. In addition, the configuration or layout of the individual components within the equipment cannot be modified or changed without qualified explanation and approval of engineer. Any deviations shall be clearly identified on submittal.

C. Prior to shipment of the air handler the installing contractor shall be fully trained on the assembly techniques to field erect the units. Training shall be completed at the manufacturer's factory in a one day class. Training shall be provided free of charge, travel/lodging and miscellaneous expenses shall be covered by the contractor.

D. Full time on-site assembly supervision by a qualified / certified AHU vendor factory employee shall be required to oversee all project activities specific to the installation, checkout, testing and startup of the AHU as specified. AHU vendor shall be responsible for the quality outcome of the air handler and correct all deficiencies identified by the engineer/owner prior to acceptance. The AHU vendor shall include in their bid all labor, meals, and travel expenses for on-site assembly supervision.

E. Pressure drop across the filter bank shall be minimum 1.5 in. w.g. and shall be included into the internal static pressure losses of the equipment.

F. Components shall be crated to minimize construction space requirements. Construction space is limited and the manufacturer shall design the unit crating to respect this limitation. Specifically, the manufacturer shall crate wall sections and necessary wall assembly components in individual crates allowing for assembly from one crate at a time.

G. The Contractor shall prepare the site, including, but not limited to ductwork, ductwork accessories, piping, piping accessories, controls, roof flashing coordination and preparation, and leveling of steel before factory supervised assembly the air handling unit. Steel support frame is to be installed to tolerance of level and flatness required by unit manufacturer. AHU manufacturer to provide onsite assembly crew supervisor to assist with

H. Manufacturer shall refer to associated custom air handling unit drawings for additional details and requirements. Refer to Controls Schematic for additional device and conduit requirements.

1.4 QUALITY ASSURANCE

A. A.All equipment or components of this specification section shall meet or exceed the requirements and quality of the items herein specified or as denoted on the drawings and schedule.

B. B.Equipment furnished under this specification shall be in accordance with the following industry, association and government codes and standards, as applicable to their design, fabrication, assembly and testing.
   1. AMCA 99 Standards. AMCA/ISO: All plenum fans shall be tested in accordance with AMCA or ISO standards for sound and performance.
   2. ARI 430 Central Station Air Handling Units. ARI Compliance: Coil shall be rated in accordance with ARI standard 410 and bear the ARI seal.
   3. NFPA 70 National Electric Code
   4. 4FPA 90A Standard for the Installation of Air Conditioning and Ventilating System NFPA Compliance: Units and components shall be designed, fabricated and installed in compliance NFPA 90A.
   5. NEMA or IP Compliance: All motors shall comply with applicable NEMA/IP standards.

C. Fans shall be rated in accordance with AMCA Standard 210 for performance and AMCA Standard 301 for sound and shall bear the AMCA seal. Motor shall meet requirements of NEMA, IEEE, ANSI, and NEC standard. Coils shall be rated in accordance with ARI Standard 410 and bear the ARI seal.

D. Equipment Listing:
   1. UL Compliance: Electrical components used shall be listed and labeled by UL.
   2. ETL Compliance: Complete unit shall be listed and labeled by ETL per standards ANSI/UL 1995 and CAN/CSA C22.2 #236-05.

1.5 ACTION SUBMITTALS

A. Submit shop drawings on air handling units. Submittal shall include all dimensional drawings with associated weights and breakdown details pertaining to shipping and rigging. Include all materials of construction as well as fabrication and connection details.
   1. Information including equipment data sheets, schedules and sketches.
   2. Equipment drawings showing dimensions, weights (shipping & operating), configuration, major component locations, access door locations, duct connection sizes and locations, and shipping split locations.
   3. Materials of construction for housing and major components
   4. Roof curbs product data.

B. Shop drawing to include plans and elevation detailing exact location of all components, access door locations with indicated swing direction, duct and piping connection sizes, shipping split locations and maintenance access clearance dimensions.
   1. Include cabinet material, metal thickness, finishes, insulation, and accessories.
   2. Casing insulation product data and performance ratings.
   3. Access door and access panel product data and performance ratings.
   4. Roofing product data and performance ratings.
   5. Louver product data and performance ratings.
   6. Paint product data and performance ratings

7. Metal grating product data and performance ratings.

C. Provide information on all coordinated conduit routing and sizing as it pertains to coordination with electrical and control system.
1. Provide complete electrical data information including wiring diagrams and accessories. Clearly indicate differentiation between factory and field wiring.
2. Electrical product data and performance ratings.

D. Provide detailed performance of all components for comparison to all scheduled values including but not limited to following: Fan manufacturer and performance curves with operating points clearly indicated. All motor size and type information. Coil selections with sizing, rows, fin spacing, face velocity, air and fluid temperatures, flow rates, pressure drops and connection sizes. heat recovery components with performance characteristics. Filter type, sizing, efficiency, and pressure drop.
1. Fans:
a. Include certified fan-performance curves with system operating conditions indicated. For fans operating at variable speeds include curves in 10 percent speed increments starting at design speed down to minimum speed.
b. Include fan-sound power ratings in all eight octave bands. Include inlet or outlet sound power levels to coincide with sound requirements indicated on Drawings.
c. Include fan construction and accessories. Submit sufficient information to show product compliance with requirements indicated.
d. Include dimensions and weight.
e. Include motor ratings, electrical characteristics, and motor accessories.
2. Vibration isolation product data with performance ratings. Uniquely identify and include information for each different isolator type and indicate for each air-handling unit where each isolator type is being used.
3. Include certified coil-performance ratings with system operating conditions indicated. Product data to include: dimensions, dry and operating weight, volume of fluid contained, materials of construction, and performance ratings with system operating conditions indicated
4. Dampers product data, including housings, linkages, and operators with performance ratings.
5. Filters product data with performance characteristics.
6. Hydronic pipe, valves, fittings, vents, strainers, and hydronic accessories product data.
7. Pipe insulation and jacket product data.

E. Provide octave band sound power levels for intake, supply and return air connections as well as radiated sound levels from enclosure.

F. Provide all factory testing data with associated testing procedures.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
1. Include in emergency, operation, and maintenance manuals.
2. Include list of all required service procedures and intervals.
3. Include list of required replacement parts for maintenance.

B. Maintenance Material

1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   a. Pre and Final Filters: One set(s) for each air-handling unit.
2. Access Door Gaskets: Recessed into the door frame and do not get tread on
3. Tool Kit: Manufacturer to provide a tool kit including special tools required for air-handling unit service.

1.7 COORDINATION

A. A.Coordinate sizes and locations of structural-steel support members, with actual equipment provided.

1.8 DELIVERY, STORAGE, HANDLING

A. Thoroughly clean equipment, components and subassemblies of water, dirt, debris, weld splatter, grease, oil and other foreign matter prior to shipment.

B. Unit to be prepped and completely sealed for protection during shipment.
1. Seal all openings in unit casings with gasketed, thin gauge sheet metal closure sheets.
2. Seal closures, caps and plugs dust-tight and moisture-tight.
3. Protect pipe flanges with plywood coverings; protect pipe threads with plastic end caps or plugs.
4. Protect machined surfaces with suitable, easily removable rust preventive.
5. Provide full charge of proper lubricant for grease lubricated bearings.
6. Provide desiccant bags or vapor phase inhibitors where required to keep components dry.

C. Ship all air handlers with complete protection from rain and dirt. Air handlers shipped on open trailers shall be protected with a minimum of two (2) layers of heavy mill shrink wrap plastic. Covering units with tarpaulins will not be acceptable since tarpaulins may damage the unit surface.

D. Units delivered with scratched, dented, or dirty surfaces or damage of any type shall be restored to “as new” condition as directed by the Architect/Engineer/Owner at no cost to Owner.

E. If equipment is to be stored before use, shipping protection provided by the unit manufacturer shall remain on the unit until the unit is installed. Manufacturer shall submit written recommendations for field storage.

F. Provide non-corrosive nameplate permanently attached to the equipment containing the following information:
1. Manufacturer’s project/serial number
2. Plant name and location
3. Customer equipment number
4. Date of manufacture

G. Deliver air-handling units with factory-installed shipping skids and lifting lugs; pack small components in factory-fabricated protective containers. Cover units with heat-shrinkable plastic sheeting suitable for shipping from point of manufacture to Project.

H. Handle air-handling units carefully to avoid damage to components, casing, and finish. Do not install damaged components; replace and return damaged components to air-handling unit manufacturer.

I. Store air-handling units in a clean dry place and protect them from weather and construction activities.

J. Keep air-handling units fully covered and protected during construction. Remove dirt and debris and clean units to a factory-cleaned condition.

K. Comply with manufacturer's written rigging and installation instructions for unloading air-handling units and moving them to their final locations.

L. For air-handling units equipped with key locks on access doors, keep doors locked during construction.
   1. If access is required within air-handling units, only open the doors to sections that require access and lock doors at the end of each workday.
   2. Protect inside of air-handling units from damage and keep inside of units as clean as the factory-cleaned condition.
   3. Report observed abuse to Owner for immediate corrective action.

1.9 PERFORMANCE TESTING (FIELD TESTING)

A. The mechanical contractor shall include in their bid price, the cost associated with hiring a Testing and Balancing Contractor to test and document all performance parameters of the air handling unit at the time of start-up. The unit design cfm and static pressure shall be delivered at a brake horsepower within 2% of design conditions. Multiple point temperature readings shall be taken down stream of the mixing section to certify that temperatures do not vary by more than 10□F across the face of the heating coil assembly.

B. Air Handler manufacturer shall perform a casing leakage test shall be performed in the field after unit is fully assembled in place. The casing leakage test shall verify the unit casing leakage is less than .5% of the design airflow when tested at 1-1/2 times the design maximum static pressure. The unit shall be sealed with blank off plates over all duct connections, pressure sections shall be put under positive pressure, negative sections shall be put under negative pressure. The leakage shall be measured in each section using a calibrated orifice plate. The total casing leakage (positive plus negative) shall be considered the sum of the positive and negative leakage. Should the unit fail first test, the manufacturer will have an opportunity to make corrections. The corrections shall not inhibit the normal use of access doors and service panels.

C. Blank-off plates shall be furnished by the AHU vendor and field installed/removed by the contractor. Installing contractor shall provide assistance to perform the leakage test.

D. Failure to pass the leakage test will subject the air handling manufacturer to penalties based upon the total energy cost for the additional leakage over .5% at $8/CFM for a minimum operating period of ten years, or up the 10% of the air handling unit cost. The University may choose to accept the reduced value or require further modifications made and the unit be tested again.

E. All test reports shall submit the documented test results directly to the Engineer. This requirement for performance testing is in addition to the adjusting and balancing requirements associated with the HVAC Contract.

F. The Contractor shall assume all responsibility for equipment installation including field assembly of individual components or sections as required.

1.10 WARRANTY

A. All equipment, materials, and workmanship shall be warranted for (12) months from startup. During the warranty period, the manufacturer shall repair or replace, at no additional cost to the Owner, any equipment, material, or workmanship in which defects may develop.

B. The manufacturer to provide full one-year parts and labor warranty after owner acceptance. The warranty labor to be performed by a factory authorized technician. Warranty work may be required after hours to accommodate owner requirements.

C. The manufacturer shall provide a corrosion warranty for the unit cabinet against general corrosion in the cabinet walls, floors, roof, doors, and fastening hardware.

PART 2 - PRODUCTS

2.1 REQUIREMENTS

A. Air handlers shall include the following minimum items in addition to those noted in the schedule or specified in this section.
   1. Field assembled (knock-down) air handling units shall be of custom construction, fabricated of reinforced aluminum and braced with steel angle framework for maximum rigidity. The support mullions will be aluminum, not steel. Panels shall be insulated; heavy gauge double wall aluminum panels load bearing and capable of forming the enclosure without additional structural members. Panels shall be joined together with independent joining member and fastened with closed end aluminum rivets or stainless-steel fasteners. Plated fasteners will not be accepted. A base rail shall be provided.
   2. Units with cooling coils shall have one continuous drain pan extending under the cooling coil sections. Drain pans are raised out of the unit base and not insulated. They are surrounded by AHU air and thus will not condense: Each coil shall include a sloped, positive-draining stainless-steel condensate pan assembly. Drain pan to be constructed from minimum 18-gauge 304 stainless steel material. Coils shall set above the condensate pan for ease of removal. Intermediate condensate drain pan shall be minimum 1-1/2” deep; extending at least 3" upstream and at least 12" downstream of the coil face. Each drain pan shall be individually piped down to the bottom pan; lower drain pan to be provided with a drain connection of sufficient size to remove condensate extended to the unit exterior for connection by others.
   3. Where the mixed air temperature in an air handling unit at the winter outdoor design temperature is less than 40 degrees F, freeze protection of the heating and cooling coils shall be provided. Coil freeze protection shall consist of run around pump.
      a. Provide hard wired freeze protection safety sensor

4. Air handling unit mixing box and outside/return air duct connections shall be configured to insure proper mixing and avoid stratification.
5. Air flow stations shall be provided to measure the
   a. Ventilation (outside) air flow
   b. Supply airflow
   c. Return airflow.
6. Water flow meters shall be provided to measure and trend heating and cooling water flow.
7. All air handling units shall have a minimum 24" access section, complete with operable doors, upstream of all coils, for cleaning and maintenance.
8. In general, air handling units shall be provided with MERV 8 pre-filter and MERV 14 final filter sections.
9. Vapor proof LED lights shall be provided inside each section of all units.
10. Exterior LED lights and GFCI outlets shall be provided on all outdoor units.

B. Provide air handling unit to fit intended use and in locations called for. Capacity, size arrangement, static pressure, brake horsepower, component parts and accessories as called for and as necessary to obtain required results and allow for proper maintenance. Guaranteed full capacity delivery through duct systems finally installed and under conditions listed. Guaranteed sound power level ratings not exceeding those of design equipment, or as scheduled.

C. All equipment shall be statically and dynamically balanced to acceptable tolerances with weights permanently fastened to fan blades, and components including the motor, installed on unit. Fan bearings shall be split pillow block and rated for L-10 life at 80,000 hours minimum.

D. Classification as designated by Unit Manufacturer based on minimum requirement listed below:

Total S.P.	Class
Up to 3 3/4 in. WG-STD	I
Up to 6-3/4 in. WG-STD	II
Up to 12-3/4 in. WG-STD	III

E. Motors: Furnished by equipment manufacturer. When VAV drives are used, the motors provided shall be matched to the adjustable speed drive selected for use. Motor to be suitable for use as a direct drive application and to be matched to fan to meet performance requirements. Provide with shaft grounding system.

F. Drives: Equipment supplier shall provide all direct drive fans. Belt driven fans are not acceptable.

G. Vibration Isolation:
1. Provide vibration isolation equipment for each fan supplied inside the air handling unit enclosures.
2. Fan and Motor mounted structural steel bases to be designed and manufactured by the fan supplier to ensure proper alignment of the fan and motor and structural integrity of the base to prevent vibration. The base shall include direct mount isolators, rubber type, 0.25-inch.

H. Fans: Fans shall be AMCA 210 certified for performance and rated in accordance with AMCA 300 for sound.

2.2 AIR HANDLING UNITS GENERAL

A. Custom built-up units shall be of the configuration, capacity and style as indicated on the drawings and Equipment Schedule and as specified herein. Through properly designed access; ease of maintenance, removability of components, and unit serviceability shall be assured.

B. The units shall be constructed for indoor installation.

C. The units shall consist of: intake sections for return and outside air, mixing section with dampers for outside air, return air and exhaust air, pre-filter section, final filter section, heating coil section, cooling coil section, humidifier section, supply and return fan sections, diffuser section, and discharge section. Refer to unit configuration as shown on the drawings.
   1. Provide fan sections, filter sections, mixing box, plenums, coil sections, heat recovery components and other sections as called for and shown on the Contract Drawings.

D. Units shall be provided with a complete lighting system with switches and receptacles, damper operators furnished and installed on all dampers, and motor wiring to safety disconnect switches.

E. Unit shall employ aluminum material (panels, bases, supports, safing, etc.) to reduce overall unit weight and minimize facility maintenance requirements.

F. Provide safing between internal components and unit casing to prevent air bypass. Safing material shall match unit interior. All seams or voids between safing, components and unit casing shall be caulked and sealed airtight.

G. Provide hygienic unit design with interior suitable for washing down. The use of support members framed within the unit casing which will allow for trapping of debris between the supports and casing will not be allowed. Unit insulation must be completely encapsulated.

H. The unit is to be shipped factory assembled in one complete section, when possible. If necessary to ship the unit in sections, due to rigging or shipping constraints, the unit is to be designed to minimize the number of sections. The unit manufacturer shall field erect the units in place at the jobsite.

I. The unit sizes shown on drawings are established based on unit performance, structural, and access requirements and are not to be altered.

J. Gauges of metal and construction to be heavy enough to prevent vibration, undue noise or breathing. Unit to be of all aluminum construction.

K. Each coil shall be independently supported so that any one coil can be removed without removing another coil. Coil racks to be stainless steel or aluminum.

L. Air and watertight sleeves, caulked and insulated where pipes and conduits penetrate unit casings.

M. All equipment within the air handling unit shall be provided with a minimum, 2” high base rail to raise equipment off the unit floor for housekeeping. Equipment mounted directly to the floor with fastener or drilled holes penetrating the water seal base is unacceptable.

N. Provide plug panels for removal of fans, motors, heat pipe and coils.

O. Any equipment flashing, internal partitions or other attachments to the casing shall be made in such a way as to ensure a permanent leak tight connection. Attachments that are bolted, screwed, or welded to or through the casing creating air bypass, air leakage or rust propagation area are not acceptable.

P. Manufacturer responsible for installation membrane flashing between factory splits. All membrane for flashing provide by unit manufacturer.

Q. Multiple section units shall be bolted together in the field using 304 stainless steel bolts, nuts and washers.

R. Underside of the unit shall be fully insulated with minimum 1.5 in. thick foam insulation covered with .040 aluminum sheeting.

S. Operating weight limit of unit is 50 lbs. /sq. ft.

2.3 FAN SECTIONS:

A. Provide fans, motors and drives of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications.

B. Plenum Type:
1. All fans shall be constructed to AMCA Standards and capacity shall be AMCA Standards 210-74 rated.
   a. Fan sections shall be complete with SWSI, arrangement.
   b. Fan shaft shall be solid 1040 or 1045 hot rolled steel that is turned, ground and polished.
   c. Fan unit shall be formed by welding heavy gauge steel inlet plate with spun inlet cones to steel angle frame.
   d. A square formed lip shall surround the unit, suitable for attachment of flex connector.
2. Fan wheels shall be non-overloading, airfoil type.
   a. Impellers shall be statically and dynamically balanced to a level of G6.3 (per ANSI 2-19) or better.
   b. Hubs shall be straight bored, keyed and set screwed to the shaft.
   c. Shafts are to be solid steel sized for first critical speed of at least 1.25 times the maximum speed for the class for class I and II fans and 1.42 times the maximum speed for class for class III and IV fans.
3. Units to incorporate multiple fans with isolation dampers for independent operation in event of a fan failure.
   a. Provide heavy duty fan inlet isolation dampers on each fan capable of withstanding 6" s.p. when closed.
   b. Dampers shall be designed to withstand velocities up to 4,000 fpm. Isolation dampers to be Ruskin Model CD50 or equivalent.
4. The blades shall be aluminum airfoil design and shall be continuously welded to the wheel shroud and backplate.
   a. The fan shall be mounted in the horizontal position and shall be an Arrangement 4.

5. Panels and framework shall be constructed of heavy gauge, precision laser cut and die formed ASTM A-569 low carbon steel to provide a rigid structure to support the shaft and bearings and reduce low frequency vibration.
6. Provide guards meeting OSHA standards at fan inlet and to completely enclose fan wheel and rotating parts.
    a. Provide flexible connection between fan inlet and inlet wall.
    b. Provide dampened thrust restraints.
7. Fans shall have a factory full spectrum dynamic balance BV-3 for Class III.
8. Bearings are to be heavy duty, grease lubricated, anti-friction, self-aligning, pillow block type and selected for minimum average bearing life (AFBMA L-50) in excess of 200,000 hours at the maximum class RPM.
    a. All bearings shall be equipped with regreasable Zerk fittings and lubrication lines extended to accessible location on fan housing for easy access for lubrication.
9. Fan shall be provided with wire mesh protective wheel enclosure and heavy gauge wire inlet screen. In the event inlet vanes are provided, fan will not require inlet screens.
10. Fan shall be cleaned, prime coated and provided with two coats of enamel final coat.
11. Each fan shall be test run at their operating speed or at the maximum RPM for the particular fan's construction class prior to shipment.
    a. The fans are to be balanced and records maintained of the readings in the axial, vertical, and horizontal direction on each of the fan's bearings. Final peak velocity measurements shall not exceed 0.1 in/sec.
12. Provide overhead beam with trolley for removal of fan motor(s).
    a. Align with motor and access panel/door.
    b. Arrangement to allow for removal of fan motor and components through the supply section into service corridor or directly to roof through outside wall.
13. Provide all fans with Piezometer rings. Transmitters by control contractor
14. Acceptable dampers:
    a. Arrow 'AFD-20'
    b. Ruskin 'CD-50'
    c. TAMCO 1500.
15. Acceptable fan manufacturers
    a. Twin City Fan
    b. Greenheck
    c. Cook
    d. New York Blower

C. Motors
1. Shall be 1170 RPM, 460V/3ph/60Hz
2. Motor shall be premium efficient, ODP / TEFC enclosure.
3. Motor shall be of HP as listed on schedule and be selected for a minimum of 10% over calculated BHP. The motor service factor shall be a minimum of 1.15. (Substitute for arr. 4 direct-drive) Motor shall be of HP listed on schedule; selected to provide adequate torque throughout entire range of fan operation and not exceed nameplate HP when fan operates at synchronous motor speed.
4. Motor shall be designed for continuous duty operation, NEMA Design B with class F insulation.
5. The motor shall be suitable for operating with variable frequency drives without undue noise, vibration or deterioration of reliability and life.
6. Motors shall be "Inverter Ready" per NEMA Std. MG1 part 31.4.4.2 and labeled as such.
7. Provide stainless steel nameplate indicating the following:
    a. NEMA efficiency index nominal efficient (MB1-12.53BO).

b. AFBMA bearing numbers.
c. Lubrication instructions.

8. Acceptable motor manufactures:
   a. Baldor
   b. Marathon Electric
   c. TECO – Westinghouse

D. The entire fan assembly shall be provided with a minimum of 18" clearance on all unattached sides for proper service access. Fan inlets to be provided with a minimum clearance distance equal to 75% of the wheel diameter.

E. The unit manufacturer shall provide flexible connection between fan and fan wall. Fan assembly shall be provided with thrust arrestors as required to prevent damage to the flex connection. Flex connection material shall be flame retardant fabric suitable for intended use meeting the requirements of NFPA 90A.

F. The fan and motor shall be factory-mounted on a spring type vibration base. The base shall be mounted on stable free standing spring isolators with 3" maximum deflection rating. Spring efficiency to be not less than 98%.

G. Fan section to be provided with structural I-beam assembly posted from the unit floor for mounting trolley to assist in motor removal; trolley assembly by others. Beam assembly to be steel construction; cleaned, prime coated and provided with two coats of enamel final coat.

H. All features, as outlined above shall be provided in order to reduce fan system maintenance downtime and minimize equipment service.

2.4 HEATING COIL SECTIONS:

A. Provide hot water heating coils of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of 550 fpm; maximum head pressure loss of 15 ft.

B. Non-ferrous heating coils, 125 psi working pressure, designed to relieve expansion and contraction strains. Minimum 16 gauge stainless steel casing, non- ferrous headers, 0.025" copper tubes with 0.035" thick "U" bends, 0.0075" aluminum fins, for coils. Coils tested at 300 psig then leak tested at 200 psig with air pressure under water. Hot water heating coils, serpentine type, number rows and arrangement as called for; same end connections with vent chamber on return end and completely drainable.

C. Coils shall be individually supported by a rack system. This rack shall allow any one (1) coil to be removed through a plug panel, without disturbing any other coil. Coils stacked one on top of the other will not be accepted.

D. The supply and return connections are to be extended and sealed through the casing wall; drain and vent connections shall be piped within the unit with ball valves (Watts Model B6000 or equal) for draining and venting of each coil. Where split coils are utilized, all internal piping within the unit shall be provided by the unit manufacturer and extended to outside of unit casing.

E. Coils shall be circuited to provide the required performance; the use of internal restrictive devices, or turbulators, to obtain turbulent flow will not be acceptable.

F. Coils shall be tested to 250 psig under water and shall be guaranteed for 200 psig working pressure.

G. Acceptable coil manufacturers:
1. Heatcraft
2. Aerofin
3. Greenheck

2.5 CHILLED WATER COOLING:

A. Provide chilled water cooling coils of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of 500 fpm; maximum head pressure loss of 25 ft.

B. Copper tubes not less than 0.025” tube wall with 0.035” thick "U" bends; non- ferrous or cast iron headers. Plate type 0.0075” aluminum fins with expanded tube. Completely drainable and able to be vented. Circuited so as to keep head loss through coil not greater than called for. Minimum 16 gauge stainless steel casings. Fin spacing to meet conditions called for. Coils bottom supply, counterflow heat transfer. Provide with Turbulators, where required to achieve scheduled performance.

C. Coils shall be individually supported by a stainless steel rack system. This rack shall allow any one (1) coil to be removed through a plug panel, without disturbing any other coil. Coils stacked one on top of the other will not be accepted.

D. Coils shall be circuited to provide the required performance; the use of internal restrictive devices, or turbulators, to obtain turbulent flow will not be acceptable.

E. Each coil shall include a sloped, positive-draining stainless steel condensate pan assembly. Drain pan to be constructed from minimum 18 gauge 304 stainless steel material. Coils shall set above the condensate pan for ease of removal. Intermediate condensate drain pan shall be minimum 1-1/2” deep; extending at least 3" upstream and at least 12" downstream of the coil face. Each drain pan shall be individually piped down to the bottom pan; lower drain pan to be provided with a drain connection of sufficient size to remove condensate extended to the unit exterior for connection by others. Recessed drain pans are not acceptable.

F. Active cooling coil condensate drain connections to be a minimum 12 inches above the bottom of the air handling unit base for trapping.

G. Where necessary to prevent moisture carryover, each coil shall have aluminum or stainless steel moisture eliminators provided on the downstream side. Cooling coils condensate pans shall be designed and manufactured to incorporate future eliminators without any field modification.

H. Coils to be sized for max velocity as indicated in the schedule.

I. The supply and return connections are to be extended and sealed through the casing wall; drain and vent connections shall be piped within the unit with ball valves (Watts Model B6000 or

equal) for draining and venting of each coil. Where split coils are utilized, all internal piping within the unit shall be provided by the unit manufacturer and extended to outside of unit casing.

J. Coils shall be tested to 250 psig under water and shall be guaranteed for 200 psig working pressure.

K. Provide removable access panels in the unit casing on each side of the unit for ease of coil removal.

L. Acceptable coil manufacturers:
1. Heatcraft
2. Aerofin
3. Greenheck

2.6 HEAT PIPE ENERGY RECOVERY:

A. Horizontal rack system with refrigerant filled 1/2 in. copper tubes with aluminum rifled fins. Stainless steel casings.

B. R410A

C. Fixed assembly with air tight seal between supply air stream and exhaust system with a foam filled double serpentine partition.

D. Pre-filter and bypass damper on both our streams.

E. Counter flow design.

F. Drain Pan: Pitch for positive drainage. Stainless steel pan construction.

G. Tested and rated AHRI certification.

H. Design Make: Innergytech

2.7 AIR HANDLING UNIT CASING:

A. Unit Casing
1. Double wall, insulated, air pressure tight, casing assemblies.
2. Aluminum panels with aluminum framing members.
3. All parts shall be aluminum, unless otherwise indicated elsewhere in this specification.
4. Where dissimilar metals are used they shall be dielectrically isolated to prevent galvanic action.
5. No through metal shall be allowed and shall be achieved with a minimum 3/8” thick epoxy bridge between metals.
6. Adhesive tapes or gaskets will not constitute an acceptable thermal brake.
7. Bolts and hardware shall be stainless steel.
8. Casing system shall be guaranteed to assure the owner that system capacity, performance, and cleanliness standards specified are not compromised. Leakage to be guaranteed at no

more than 1/2% of the design volume at 1-1/2 times the design operating pressure or 30 CFM, whichever is greater.

9. All casing walls shall be of panel construction, including but not limited to the fan discharge walls, mixing section walls and divider wall to the access corridor.
10. Panel system shall incorporate an integral thermal break system downstream of cooling coil such that there is no through metal path between the interior and exterior surface of the unit casing at all locations.
    a. The thermal break shall consist of a minimum 1/2" structural epoxy bridge. Adhesive tapes or gaskets do not constitute an acceptable thermal break.
    b. Criteria to evaluate requirement for thermal break system shall be based upon scheduled unit performance and ambient conditions anticipated around the units.
11. Any equipment flashing, internal partitions or other attachments to the casing shall be made in such a way as to ensure a permanent leak-tight connection.
    a. Attachments that are bolted, screwed, or welded to or through the casing creating air bypass, air leakage or rust propagation areas are not acceptable.
12. All ductwork penetrations through unit enclosure shall be provided with framed openings of size and arrangement as indicated on drawing.
    a. Openings to be provided with flanged duct connections of same material as casing interior extending a minimum of 4” from surface of unit casing.
13. Pipe and conduit penetrations through the unit casings shall be provided by the unit manufacturer and be properly sealed prior to leaving the factory. Penetrations sealed by simply caulking around extension are not acceptable.

B. Unit Panels
1. Panels minimum 2-1/2 in. thick, with minimum 0.040 in. Stucco aluminum gauge solid exterior sheet and 0.040 in. gauge solid inside sheet.
2. Panels filled with 3-pcf high density polyisocyanurate foam insulation. The panel R value shall be a minimum of 12 or greater
3. Wall panels shall be continuously sealed (gasketed) between interior and exterior skin.
4. Spot welding or mechanical fasteners shall be on 6 in centers maximum.
5. The maximum allowable panel deflection is 1/200th of the panel span at the full rated unit static pressure.
6. Thermal brake and panel insulating coefficient shall be designed to guarantee that casing will not sweat with exterior conditions of 91Fdb/74Fwd and interior conditions of 55Fsat.
7. Interior space packed with blown foam.
8. Panel U-value shall not exceed 0.049 BTU/hr./sq.ft/°F. UL fire rating; flame spread - 10-20, fuel contributed - 1015, smoke developed - 0-20.
9. Each panel shall contain an integral frame or be properly supported by a structural framing system.
10. Panel shall have continuous tight seal at the interior and exterior skins completely encapsulating the insulation.

C. Service Access Doors
1. Access doors for serviced access between each section.
2. Door swing to be based on pressure differential direction of flow so that doors are pushed closed and not open when unlatched.
3. Removable access panels shall be provided for service and maintenance.
4. Access panels shall be of the same construction as panels described above.
5. Removable access panels shall be designed and constructed such that removal and replacement may be accomplished without disturbing adjacent panels.
6. Airtight integrity must be maintained.

D. Base Rails
   1. Units to have aluminum channel base rail of sufficient depth for proper unit support.
      a. The unit shall be constructed on an all-aluminum or stainless steel structural base.
      b. The base shall be designed to distribute loads properly to a suitable mounting surface and be braced to support internal components without sagging, pulsating or oil canning.
   2. Unit floor in air handling sections shall be 3/16" minimum thickness aluminum checker plate with continuous 2 inch raised lip at perimeter of unit and between sections and fully welded watertight (spot welding or threaded fasteners sealed watertight is not acceptable).
   3. Provide individual drains in each section of the air handling unit extended to unit exterior base and (capped) for piping trap connections in the field.
   4. All section or compartments of the unit shall be fully drainable.
   5. The floor plate thickness and supports shall be sufficient to avoid any "tin canning" when 200 lb. point loading is applied to the flooring system.
   6. Floor pan shall be foam insulated to prevent condensation and sealed with exterior aluminum skin.
   7. Recessed inside of unit base for outdoor units. Skins fastened to bottom of unit support rails are not acceptable.
   8. The base floor is to be supported with adequate stiffening members to prevent oil canning.
   9. Caulking, gaskets and mechanical fasteners to guarantee seals and water tightness of joints will not be acceptable.
   10. The perimeter support members shall be a minimum of 6” structural member properly sized to support all major components and the housing during rigging, handling and operation of the unit.
   11. Each section of the unit base shall contain a minimum 1” NPT drain to facilitate system washdown, maintenance and condensate removal. Areas in the base where potential standing water cannot be removed through drains or weep holes are not acceptable. Clean out drains shall be provided with removable caps of non-corrosive material.
   12. All equipment within air handling unit shall be provided with a minimum 2" high base to raise equipment off unit floor for housekeeping. Equipment mounted directly on unit floor is unacceptable.
   13. Supply air openings to be framed with 2” high water dam continuously welded to the pan to allow proper duct connections and to prevent moisture from entering the openings. Framed openings shall be provided with removable aluminum or 304 stainless steel grating designed and fabricated for a live load of 100 pounds per square foot. Galvanized or painted steel grating will not be accepted.
   14. All unit base service openings shall be framed with a minimum 2” high water dam continuously welded to the floor. All pipe and electric conduit chases with openings to building or elements shall be covered with thin gage aluminum or 304 stainless steel. Penetrations by contractors shall be sealed by the respective contractor.
   15. Fastening to floor plate or joining of unit sections to be accomplished by bolting through gasketed joints above the floor line or continuously welding. Fasteners which penetrate base floor plate are not acceptable.
   16. Unit to be provided with properly located permanent lifting plates or removable lifting lugs for each section to adequately allow rigging of the unit sections in place.

E. Door Panels
   1. Constructed of same material and gauges as panels.
   2. Minimum door size of 24 in., 2-1/2 in. thick of the overlapping seal type.

3. Doors shall be supplied with continuous non-pitching gaskets.
   a. The access doors shall incorporate two continuous separate gasket seals around the entire periphery of the door.
   b. Gasket material shall be UV-resistant, closed cell neoprene; gaskets shall be attached by adhesive and not mechanically held in place.
   c. Single gasket seals will not be accepted.
4. Doors to be supplied with stainless steel piano hinges.
   a. Each access door shall be mounted with a corrosion-resistant continuous piano hinge and shall have a least two (2) non-corrosive handles operable from either side.
5. Minimum of two cast aluminum or fiber reinforced plastic door latches with an inside release handle.
6. Doors shall be assembled with hinge hardware attached and adjusted in the field.
7. Door latches wedge lever type with handles inside and outside.
8. Hinges designed for door size and weight.
9. Doors installed to open against the air pressure.
10. Provide 1" dia. test ports with screwed caps on casing upstream and downstream of all coils and filters for pressure and temperature measurement.
11. Interior doors shall have 10 in. (min.) square thermal pane windows.
    a. Each access door shall contain a thermopane safety glass window (min. 10" square).
12. All doors serving fan sections or other rotating equipment shall be provided with lockable type hardware.
13. A door entering into rotating components of the air handling unit shall be provided with signage indicating "Do Not Enter – Rotating Machinery".

F. Roof
1. Roof channels, aprons and corners joined of aluminum and formed to prevent a direct path for sound and/or air leakage.
2. Panel joiners 20 gauge minimum.
3. Where these roll formed joiner sections are not utilized, 16 gauge minimum.
4. Panel joiners and connectors shall allow for expansion.

G. Framed Openings
1. Provide framed openings fittings with curved bell mouth fittings.
2. Bell mouth fittings shall have a minimum smooth radius equal to 20% of the diameter or shortest side (rectangular) to provide optimum performance.
3. Unless otherwise noted on drawings.

H. Structural System
1. The structure shall be fully self-supporting.
2. Where roof spans and wall loadings require additional structural strength, it shall be furnished either by heavier roof and wall joiners, or, additional structural members capable of withstanding a differential pressure of 10 in. w.g.
3. Unit built on unpainted aluminum base channel.

2.8 OUTSIDE AIR SECTION

A. Outside air shall be admitted and exhaust air shall be discharged through storm-proof, extruded aluminum or stainless steel louvers, minimum 3-1/2" deep with aluminum or stainless steel

birdscreen and aluminum or stainless steel weather hoods. Weatherhood exterior to match the finish of the unit casing.

B. Outside air shall be admitted through drainable blade stationary fog-type louver. Louver shall be certified storm-proof, extruded aluminum, with aluminum birdscreen. Louver to be Cesco Products, Type ASL6.

C. Louver shall have AMCA certified air performance and water penetration ratings.

D. Louver to be provided with a low-leakage outside air damper. Dampers shall be as specified below and shall be furnished and installed by the unit manufacturer.

E. Outside air intake shall be sized for a maximum of 450 fpm. Exhaust air discharge shall be sized for a maximum of 750 fpm.

2.9 FILTER SECTIONS:

A. Provide all prefilters and final filters of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Filters to be selected for a maximum face velocity of 500 fpm.

B. Filters shall have nominal rating of 500 fpm. Each cell shall be 24" x 24", or 12” x 24”. Initial pressure drop shall not exceed that indicated. Media shall be approved and listed as Underwriters Laboratories Class 2 when tested according to UL Standard 900 and as described below:
   1. Prefilters: 2" thick MERV 8 efficiency (per ASHRAE Test Standard 52.2-2007), and MERV 12 (per ASHRAE Test Standard 52.2-2007), rigid disposable filters.
   2. Final Filters: 12” rigid type, MERV 14 (per ASHRAE Test Standard 52.2-2007), rigid disposable filters.

C. Factory install all filter holding frames in support racking by bolting or riveting. Seal between all filter frames. Provide all required holding clips. Include mounting rack for
   1. Filter frames to be 304 stainless steel.
   2. Filter banks shall be reinforced with vertical stiffeners to assure rigidity, and providing flashing between filter banks and unit casings to air leakage or bypass around the frames.
   3. Provide mounting rack as indicated on drawing and specified.

D. Filters shall be upstream removable. Side access is not acceptable. Pre-filter sections shall be complete with holding frames capable of holding prefilters with high efficiency filters. Prefilters shall be capable of being removed and installed without affecting seal of the high efficiency filter.

E. Filter holding frames shall be installed and individually sealed to prevent leakage around frames. Filter banks shall be reinforced with vertical stiffeners to assure rigidity. Unit manufacturer shall provide flashing between filter banks and unit casings to prevent air leakage or bypass around the frames. Installation techniques, sealing methods, and structural reinforcement eliminate unfiltered air bypass and assure system cleanliness based on filter efficiencies specified.

F. Unit manufacturer shall provide and install a Dwyer series 2000 magnehelic gauge complete with stainless steel static pressure tips and accessories for indicating the operating pressure drop of each filter bank.
   1. Indicating range of gauge shall be selected at two times the final resistance of the filter bank.
   2. Gauge to be 3-7/8 in. diameter white dial diaphragm actuated.
   3. Guaranteed accurate to + 2% of full scale.
   4. Pointer zero adjustment.
   5. Provide all accessories including adapters, mounting panel, pressure tips, fittings, tubing, vent valves.

G. Provide access doors for replacing filters and access to dampers.

H. Acceptable filter frame and filter manufacturers:
   1. American Air Filter
   2. Farr

I. Provide one complete extra full set of filters.

2.10 MIXING SECTION

A. Complete with framed openings with low-leakage outside and return air dampers. Dampers shall be as specified below and shall be furnished and installed by the unit manufacturer.

B. Mixing section shall be designed for controlled mixing in that the proximity, relation, and air velocity for each respective damper shall be such that volume swings and stratification will be eliminated.

C. Outside air damper banks incorporating minimum outside air to be provided with an independent damper with independent control for minimum outside air. Minimum outside air provided by controlling outside air damper bank to a minimum position will not be acceptable.

2.11 DAMPERS

A. Return, Exhaust, Bypass, Fan isolation and Outside Air Damper:
   1. Dampers shall be low leakage, opposed blade design capable of withstanding 8” wg differential pressure at 2,000 fpm approach velocity.
   2. Leakage rate not to exceed 6 CFM per ft.2 at 4” wg differential pressure and 2,000 fpm approach velocity.
   3. Dampers shall be opposed blade, unless otherwise noted on drawings, aluminum, airfoil, and low leakage type design.

B. Damper frames shall be made of extruded aluminum.
   1. Damper blades shall be extruded aluminum airfoil shape to withstand high velocities and static pressures.
   2. Dampers shall be provided with stainless steel blade end seals and flexible synthetic blade edge seals.
   3. Blade and frame seals shall be of extruded silicone.
   4. Seals are to be secured in an integral slot with the aluminum extrusions.

C. Bearings shall be composed of a Celcon inner bearing fixed to an aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to- plastic contact.

D. Linkage hardware shall be installed in the frame side and constructed of aluminum and corrosion-resistant, zinc-plated steel, complete with cup- point trunnion screws for a slip-proof grip.

E. Dampers are to be designed for operation in temperatures ranging between -40°F and 212°F.

F. All dampers shall be arranged within the air-handling unit to allow the actuators to be installed within the enclosure of the units and not mounted at the unit exterior unless otherwise noted on drawings. All dampers to be surface mounted to allow for direct connection of actuators on drive shaft.

G. Unit(s) shall include separate minimum outside air dampers where shown on drawings. Minimum outside air opening shall be sized and arranged to accommodate outside airflow measurement station.

H. Where multiple dampers are installed end to end, satisfactory clearance shall be maintained between linkages to allow for actuator linkage connections. Actuation linkage not to be attached to face of damper. Minimum damper blade width shall be 6".

I. Damper actuators to be mounted by unit manufacturer.
   1. Damper actuator to be supplied by control contractor and mounted in the factory.
   2. Actuators for dampers with modulating control to be provided with pilot positioners.

J. Equipment Manufacturers
   1. Basis of Design Equipment: Ruskin ‘CD-50’
   2. Acceptable Makes:
      a. Arrow ‘AFD-20’
      b. TAMCO 1500
      c. Greenheck.

2.12 UNIT DISCHARGE SECTION

A. Discharge section with exit velocities exceeding 2000 fpm shall be complete with aerodynamically designed framed discharge openings or spun bellmouth fittings in order to reduce overall system static pressures.

B. Bellmouth fittings shall have minimum radius equal to 20% of the diameter (round or oval) or shortest side (rectangular) to provide optimum performance. Bellmouths with radius less than 2” are not acceptable. Bellmouth to be mounted flush with unit interior edge to minimize exit loss.

C. Openings shall conform to the size and configuration of the ductwork where shown.

D. Smoke DETECTOR shall be furnished and installed by the unit manufacturer for supply air (and return air) openings as shown on the drawings. Dampers shall be as specified below:

2.13 UNIT RETURN SECTION

A. Return section with ilet velocities exceeding 2000 fpm shall be complete with aerodynamically designed framed discharge openings or spun bellmouth fittings in order to reduce overall system static pressures.

B. Bellmouth fittings shall have minimum radius equal to 20% of the diameter (round or oval) or shortest side (rectangular) to provide optimum performance. Bellmouths with radius less than 2" are not acceptable. Bellmouth to be mounted flush with unit interior edge to minimize exit loss.

C. Openings shall conform to the size and configuration of the ductwork where shown.

D. Smoke DETECTOR shall be furnished and installed by the unit manufacturer for return air and return air openings as shown on the drawings.

2.14 ELECTRICAL

A. All electrical work shall be installed in full compliance with the National Electric Code, and all local codes and requirements. Where applicable, components shall be UL approved. All wiring and components inside air handling plenums shall be weatherproof and rated for such use. All equipment shall contain a grounding conductor.
   1. WIRING: 600 volt rated, type #12 THHN copper (minimum size).
   2. CONDUIT: EMT Aluminum rigid conduit utilizing compression type fittings. All conduit penetrations in the unit housing and penetrations across the cooling coil sections and humidifier sections shall be internally sealed with foam sealant to prevent the migration of water vapor in the conduit.

B. The Mechanical Contractor shall hire an electrical contractor to be responsible for mounting and wiring the all of devices on the air handler as detailed in the contract documents. The required installation labor, conduit, wiring, and miscellaneous fittings shall be provided by the electrical contractor. All internal conduit to be aluminum.

C. Unit manufacturer shall furnish, a complete lighting system to one (1) identified 120 volt feed location. Lighting system to include light fixtures, switches, and a GFCI receptacle per the following:
   1. LIGHT FIXTURES: vapor tight incandescent marine type guarded service light fixture, LED lamp for each section of the units. Each access section to be provided with minimum of one (1) light fixture. Fan sections and filter sections to be provided with minimum of two (2) light fixtures. Access corridors to have a minimum of three (3) light fixtures.
   2. LIGHT SWITCHES: 20 AMP, single pole, specification grade, toggle switch in lug type device box with stainless steel weatherproof cover.
   3. GFCI CONVENIENCE OUTLETS: 20 AMP, specification grade, NEMA 5-20R, duplex receptacle in lug type device box with stainless steel weatherproof cover. Unit to be provided with four (4) convenience outlet. One (1) on unit exterior at the fan section.

D. Unit manufacturer shall furnish, a safety switch / fan motor disconnect for each fan motor to one (1) identified 460 volt feed location. Final connection to motors shall be made through Sealtight flexible conduit.

1. FAN MOTOR DISCONNECTS: 3 pole, 600V, horsepower rated, heavy duty, visible blade, non-fused, NEMA 3R or 4 safety switch with 2 pole control circuit interlock if used in conjunction with variable speed drive.
2. Provided with the VFD.

E. Field wire unit on site to include power for fans, lights, VFD, general power and controls.

2.15 SMOKE DETECTOR

A. Smoke Detector: Field provide and install Smoke detector shall be listed for Building fire alarm systems. Refer to section 283111 Digital, Addressable Fire-Alarm System.

2.16 ACCESSORIES:

A. Furnish internal industrial grade moisture proof lighting within each section of the unit that has an access door. Lighting shall be wired back to timer switch, each section shall include a light and timer switch. The lighting shall be LED vapor tight fixtures.

B. All fans shall be field wired to a junction box mounted in service corridor. Installation of all wiring and conduit shall be in conformance with NEC. (Coordinate with single point power, VFDs, multiple feeds)

C. Provide a minimum of four (4) 3/4 inch diameter pipe penetrations, air tight, with threaded connections through the exterior and interior of unit for field use by the Installation Contractor. The pipe penetrations shall be spaced evenly along the length of the unit and shall be located on the same side as the access doors. The pipe penetrations shall be located 1'-0" down from the top of the air handling unit enclosure. Coordinate with Controls Contractor.

D. Provide in all units, in each fan section, an overhead telescoping beam with trolley for fan motor removal/replacements for a fan motors over 15HP.

2.17 AIR FLOW STATIONS:

A. Provide airflow measurement provision and transmitters for the purpose of continuously monitoring unit airflow volume.

B. Provide airflow measuring devices at the AHU supply, return, exhaust, minimum outside air, and economizer outdoor air sections. Airflow measuring device should be capable of measuring the entire airflow range.
1. Fan airflows shall be measured with direct measurement at the fan inlets. All other locations shall be achieved with duct mounted airflow stations.

C. The airflow measurement system shall consist of a piezometric flow ring incorporated into the inlet of the fans. Ring shall consist of a minimum of four orifice ports strategically located in the throat of the fan inlet; orifice taps to be piped with tubing in a continuous ring. Tubing to be extended to accessible location for connection to flow transmitter.

D. Fans to be provided with piezo rings Piezometric ring to be provided integral with the fan construction.

E. BMS contractor to provide all transmitters and OA flow stations.

F. Provide mounting brackets for all electrical panels, control panel enclosures and adjustable speed drives as indicated on control drawings. All locations to be coordinated with installing contractors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. After completing the installation, inspect the air handler for damage, dirt or debris. Remove all dirt, construction debris and repair any damage to the finish including chips, scratches or dents.

B. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

C. Examine air-handling units before installation. Reject units with physical damage, and air-handling unit components that are wet, moisture damaged, or mold damaged.

D. Examine roughing-in for the following before installation of air-handling units:
1. Structural substrate mounting and anchorage to verify actual sizes, types, and locations.
2. Piping systems to verify actual sizes, types, and locations of connections.
3. Ductwork and plenums to verify actual sizes, types, and locations of connections.
4. Electrical services and controls to verify actual sizes, types, and locations of connections.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

F. Replace the filters used during the construction phase

3.2 INSTALLATION

A. The AHU shall be Built-In-Place in the field by the Mechanical Contractor. The Mechanical Contractor shall provide all trades required to achieve a complete assembly including but not limited to Power and controls. Mechanical Contractor shall obtain he services of qualified licenses tradesmen to complete the field power and control installation for this unit.

B. Install unit per manufacturer’s recommendations and instructions as described in the Installation, Operation and Maintenance (IOM) manual.

C. Prior to the installation of the air handler, the mounting surface shall be confirmed smooth and level to a tolerance of ¼” over the air handler length. All existing mounting surfaces shall be repaired and/or sealed as required.

D. The installing contractor shall mount the air handler using necessary base shims to assure a level installation and proper air handler operation.

E. Contractor shall NOT use the units to provide temporary heating, cooling or ventilation to the building during construction. 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.

F. Equipment Mounting: Install air-handling units at locations indicated on Drawings. Unless, otherwise indicated on Drawings, install air-handling units on concrete equipment bases.
   1. Install air-handling units on curbs following air-handling unit manufacturer's written procedures.
      a. Install gaskets before setting air-handling units on curbs.
      b. Secure air-handling units to curbs using stainless steel fasteners.
      c. Install curb and fasten to structure.
      d. Coordinate curb requirements, attachment, and location before installation.

G. 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.

H. Equipment Clearances and Access:
   1. Arrange installation of air-handling units to provide access space around air-handling units for service and maintenance and for removal and replacement of internal components.
   2. Provide clearance and access required by governing codes and NFPA 70.
   3. At a minimum, comply with requirements indicated on Drawings and air-handling unit manufacturer's written instructions.

3.3 LIFTING INSTRUCTIONS

A. Performance air handlers must be rigged, lifted, and installed in strict accordance with the Installation, Operation, and Maintenance manual for air handlers. The units are also to be installed in strict accordance with the specifications.

B. Units shall be shipped on an integral 6" base frame for the purpose of mounting units to a housekeeping pad and providing additional height to properly trap condensate from the unit.

C. Each indoor unit section to be shipped with 4 lifting lugs for proper lift and installation. Indoor to also be shipped with a shipping skid designed for forklift transport.

D. Per ASHRAE 62.1 recommendation, indoor air handling units to be shipped stretch-wrapped to protect unit from in-transit rain and debris.

E. Installing contractor is responsible for long term storage in accordance with the Installation, Operation, and Maintenance manual.

3.4 PROTECTION DURING CONSTRUCTION

A. Exterior Covers: Cover air-handling units during construction with sealed covers to protect air-handling unit casing and externally mounted components from physical damage, dirt, dust and debris, paint splatter, and any other construction materials.
   1. Minor physical damage, as determined by Owner, shall be repaired by air-handling unit factory service personnel to factory-finished condition.

2. Replace air-handling units with damage that in any way compromises the performance indicated.

B. Internal Access: Keep access doors locked to maximum extent possible and restrict access to only authorized personnel.
1. Open access doors only during periods authorized work inside air-handling units is required.
2. Coordinate and monitor work inside air-handling units on a shift basis. Lock access doors once work is complete or at the end of each shift.
3. Immediately report unauthorized access and any observed damage to Owner.

3.5 DUCT CONNECTIONS

A. Connect ducts and plenums to air-handling unit connections. Comply with requirements in Section 233113 "Metal Ducts."

B. onnect ducts and plenums to air-handling unit connections with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

C. Provide duct transitions required to make field connections to air-handling units.

D. Arrange ducts and plenums to provide unobstructed access to inside of air-handling units.

3.6 PIPING CONNECTIONS

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

B. Where installing piping adjacent to air-handling unit, provide unobstructed access to inside of air-handling units for service and maintenance.

C. Connect piping to air-handling units with flexible connectors.

D. Drain Pan Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
1. Make connections to air-handling unit connections with flanges .
2. Extend dedicated drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
4. Coordinate piping arrangements to allow access to traps in condensate drain below AHU floors.
5. Install threaded cleanouts at changes in direction.
6. Secure drain piping to structure.

E. Chilled-and Hot-Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
1. Comply with requirements indicated on Drawings.
2. Make connections to coils with a flange.

3. Connect to each coil inlet with shutoff valve, test plug, pressure gauge, and thermometer.
4. Connect to each coil outlet with balancing valve, test plug, pressure gauge thermometer, flow meter, and shutoff valve.
5. Connect each coil drain connection with a drain valve, which is full size of drain connection. Connect drain pipe to drain valve with union, and extend drain pipe to connect to storm drain system.
6. Connect each coil vent connection with manual vent, which is full size of vent connection.

3.7 ELECTRICAL CONNECTIONS

A. AHU shall be fully assembled on site and all electrical work shall be field wire by the Mechanical Contractor. Mechanical Contractor shall obtain the services of a License Electrical Contractor to wire the units in the field as it is being erected.

B. Install field power to each air-handling unit electrical power connection. Coordinate with air-handling unit manufacturer and installers.

C. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

E. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

F. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.8 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.

D. Smoke Detector
1. Where duct mounted smoke detectors are required by the 2020 New York State Uniform Fire Prevention and Building Code, and noted in this specification, the preference is to have the device factory mounted and provided as part of an assembly.

3.9 STARTUP SERVICE

A. Engage an air-handling unit factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with 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, controls, 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 face-and-bypass dampers provide full face flow.
7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
8. Comb coil fins for parallel orientation.
9. Verify that proper thermal-overload protection is installed for electric heaters.
10. Install new, clean filters.
11. 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.

3.10 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

C. Before turning equipment over to Owner for use, adjust air-handling unit components that require further adjustment for proper operation. Consult air-handling unit manufacturer for instruction.

D. Occupancy Adjustments: When requested within [12] <Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two] <Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

E. Seasonal Adjustments: Make seasonal visits during warranty period to inspect and review operation of equipment. Make necessary adjustments for components observed to require adjustments for proper operation. Prepare and submit a report to Owner documenting each visit, observations, and any adjustments made.

3.11 FIELD CLEANING

A. Cleaning Schedule: After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before Owner use, clean air-handling units to remove foreign material and construction dirt and dust.

B. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.
1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
3. Clean all internal components, such as, coils, dampers, filter frames, fans, and motors.
4. Clean light fixtures and control devices.

C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.

D. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.

E. Acceptance: Following unit cleaning submit a written request for review and Owner acceptance. Acceptance for cleaning of air-handling units must pass a white glove test.

3.12 FIELD QUALITY CONTROL

A. After the equipment is installed, the manufacturer’s representative shall inspect the installation and recommend any corrective actions. Do not startup the equipment until the following operations are completed:
1. Power is connected to the unit.
2. Shipping materials have been removed.
3. Filtration media is installed and clean.
4. Piping and duct connections are installed and operational.
5. Leak checks are completed on all water connections.
6. All wiring, gasketing and hardware are properly installed on any multiple section units.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
1. After field piping connections are complete, test hydronic coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Field-Assembly Supervision: Instruct Installer and supervise field installation of first air-handling unit(s) shipped in multiple pieces for field assembly.
4. Roof-Mounted Field-Installation Supervision: Instruct Installer and supervise field installation of first roof-mounted air-handling unit(s).

5. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Field Casing Leakage Test:
1. Perform leak testing of air-handling units that include field assembly of multiple sections. Air-handling units that are shipped and installed as a single piece do not require field testing.
2. Leak test one air-handling unit(s) of each unique size and arrangement randomly selected by Commissioning Agent.
3. Follow procedures complying with ASHRAE 111.
4. Assembled air-handling units shall satisfy leakage criteria indicated. Modify air-handling units that fail to satisfy criteria and retest. For every air-handling unit that fails test, another air-handling unit shall be tested until all air-handling units tested pass leakage criteria on first attempt.
5. Submit a test report for each test indicating test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.
6. Test report shall be in accordance with ASHRAE 111.
7. Witness Testing:
   a. Provide written notification at least 30 business days in advance of testing.
   b. Testing shall be conducted in presence of testing and balancing agent.
   c. Other parties such as Architect, Commissioning Agent, and Owner shall be invited to witness testing with attendance being optional.

F. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

G. Prepare test and inspection reports.

3.13 OPERATION DURING CONSTRUCTION

A. Operation of air-handling units for temporary cooling, heating, and ventilation **is not allowed without Owner authorization.**
1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:
   a. Description of construction activities while units are operating.
   b. Operation:
      1) Beginning and ending calendar dates.
      2) List each day during week.
      3) List start and stop time and hours for each day.
   c. Startup procedures and shut-down procedures.
   d. Provisions for routine monitoring of unit operation.
   e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage and current and electrical fault.
   f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
   g. Record keeping.
2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit

labor and parts warranty to extend at least [two] <Insert number> years after the warranty indicated expires.

3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner.

B. Filtration During Temporary Use:
   1. Protect air-handling system ducts (exhaust air, outdoor air, and return air) with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 13 in accordance with ASHRAE 52.2.
   2. Protect air-handling units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and by-pass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 8 in accordance with ASHRAE 52.2.
   3. Do not operate air-handling units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
   4. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting and balancing.

C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.14 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 outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
   7. Comb coil fins for parallel orientation.
   8. Install new, clean filters.
   9. 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.
   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.

3.15 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing

3.16 DEMONSTRATION

A. Engage air-handling unit manufacturer factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

B. Training shall include, but not be limited to, procedures and schedules related to performance, safety, startup and shut down, troubleshooting, servicing, preventive maintenance, and how to obtain replacement parts.
   1. Access Doors: Adjustment, gasket removal and replacement, handle removal and replacement, and spare parts.
   2. Access Panels: Removal and replacement, adjustment, gasket removal and replacement, and spare parts.
   3. Air Blenders: Cleaning, operation, removal, and replacement.
   4. Coils: Cleaning, combing fins, draining, venting, removal, and replacement.
   5. Controls: Calibration, cleaning, operation, service, removal and replacement, and spare parts.
   6. Damper Assemblies: Cleaning, operation, service, removal and replacement, and spare parts.
   7. Drain Pans: Cleaning, removal, and replacement.
   8. Fan and Motor Assemblies: Cleaning, operation, removal and replacement, service, and spare parts.
   9. Filters: Operation, removal and replacement, frame gasket removal and replacement, clip removal and replacement, and spare parts.
   10. Lights, Receptacles and Switches: Cleaning, operation, service, removal and replacement, and spare parts.

C. Instructor:
   1. Instructor shall be factory trained and certified by air-handling unit manufacturer with current training on equipment installed.
   2. Instructor's credentials shall be submitted for review by Commissioning Agent[before scheduling training.
   3. Instructor(s) primary job responsibility shall be Owner training.
   4. Instructor(s) shall have not less than three years of training experience with air-handling unit manufacturer and past training experience on at least three projects of comparable size and complexity.

D. Schedule and Duration:
   1. Schedule training with Owner at least 20 business days before first training session.
   2. Training shall occur before Owner occupancy.
   3. Training shall be held at mutually agreed date and time during normal business hours.
   4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for a one-hour lunch period and 15-minute break after every two hours of training.

5. The following training shall be accomplished after the completion
   a. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   b. Provide a total of eight (8) hours of instruction at the site, during start-up.
   c. Provide six (6) hours of instruction at the site after start-up
      1) Provide two (2) hours at three (3) months after start-up training
      2) Provide two (2) hour at six (6) months after start-up training.
      3) Provide two (2) hour at nine (9) months after start-up training

E. Location: Owner to provide a suitable on-site location to host classroom training.

F. Training Attendees: Assume three people.

G. Training Attendance Records: For record purposes, document training attendees at start of each new training session. Record date, time, brief description of training covered during the session, attendee's name, signature, phone number, and e-mail address. Submit scanned copy of sign-in sheet to Owner for each training session.

H. Training Format: Individual training modules to include classroom training followed by hands-on field demonstration and training.

I. Training Materials: Provide training materials in electronic format to each attendee.
   1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.

J. Training Video Recording: Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.

K. Written Acceptance: Obtain Commissioning Agent written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 237313

SECTION 237343.19 - OUTDOOR, CUSTOM ROOF TOP UNIT

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 of the work includes the design, fabrication, testing, cleaning and packaging, shipment, final assembly and installation of custom built-up air handling units.

B. Provide all labor, materials, equipment, and services to perform all operations required for the complete installation as shown on the Contract Documents.

C. Related work specified elsewhere:
1. Section 23 – Motors
2. Section 23 – Adjusting and Balancing
3. Section 23 – Building Automation and Controls
4. Section 23 – Air Filters
5. Section 23 - Coils

D. RTU shall have service access corridors with all piping, access doors, and controllers inside.

E. Section includes outdoor, custom air-handling units with capacities, characteristics and configurations indicated on Drawings.
1. SMACNA leakage class rating of 5.0
2. Maximum panel deflection shall not exceed L/200 at design total static pressure
3. Minimum R-12 insulation value for walls, ceilings, and flooring
4. Minimum R-12 insulation value for Roof
5. 2-1/2” Double wall thermal-break panels (walls, Floor, Roof)
6. 0.040" aluminum outer wall, 0.040" aluminum inner wall
7. 2 lb/ft3 polyurethane foam injected insulation in the walls and ceiling
8. Designed for outdoor installation.
9. Unit roofs for outdoor units are to be sloped a minimum of 1/4” per foot to assure positive run-off. Roof to peak in center and drain off to both sides / on door side and drain away from door side.
10. The entire roofing system shall be a polymer membrane permanently bonded to the unit roof. Membrane to be minimum 0.045” thick. Standing seam roofing system will not be acceptable.
11. Unit shall be provided with a non-corrosive rain gutter system with downspouts to guide unit roof water run-off to the building roof. Units incorporating roof systems without controlled water run-off accommodations are not acceptable.
12. Manufacturer responsible for installation membrane flashing between factory splits. All membrane for flashing provide by unit manufacturer.

13. Unit shall be shipped in Multiple sections. Sections shall be reassembled in the field. All silicone, gasketing, flashing and fasteners required to reassemble the unit sections shall be provided and shipped loose inside the unit sections.
14. Maximum weight as per schedule shall not be exceeded
15. Mechanical Contractor shall be responsible for any schedule or specification deviation in performance, specifics or construction.
16. Fan motors shall have individual controllers.
17. Perforated liner is to be provided in the fan sections for additional sound attenuation.
18. Controls are to be provided by others and mounted/wired in conduit.

F. RTU shall be fully assembled on site and all electrical work in the field shall be field wire by the Mechanical Contractor. Mechanical Contractor shall obtain the services of a License Electrical Contractor to wire the units in the field as it is being erected.

1.3 MANUFACTURER'S (EQUIPMENT SUPPLIER'S) GENERAL REQUIREMENTS

A. Design Equipment
1. Basis Of Design Equipment: Air Enterprises
2. Acceptable Makes: Environmental Air Systems, Buffalo Air Handling.
3. Alternate manufactures must receive written permission to bid via Addendum 15 days prior to the bid and follow the Alternate procedure outlined in Specification DIVISION 01
4. The unit manufacturer shall have been manufacturing custom built-up air handling units for a minimum of 20 years.

B. It is the intent of these specifications and referenced specification sections to provide the minimum design and performance parameters without being proprietary toward a specific equipment supplier. It is the responsibility of the listed acceptable equipment suppliers to meet the basic intent of the specifications and drawings. The overall "box" size of Air Handling Units as shown on Drawings shall not be deviated from. It is not the option of the equipment supplier to increase or decrease the physical size of the equipment. In addition, the configuration or layout of the individual components within the equipment cannot be modified or changed without qualified explanation and approval of engineer. Any deviations shall be clearly identified on submittal.

C. Prior to shipment of the air handler the installing contractor shall be fully trained on the assembly techniques to field erect the units. Training shall be completed at the manufacturer's factory in a one day class. Training shall be provided free of charge, travel/lodging and miscellaneous expenses shall be covered by the contractor.

D. Full time on-site assembly supervision by a qualified / certified RTU vendor factory employee shall be required to oversee all project activities specific to the installation, checkout, testing and startup of the RTU as specified. RTU vendor shall be responsible for the quality outcome of the air handler and correct all deficiencies identified by the engineer/owner prior to acceptance. The RTU vendor shall include in their bid all labor, meals, and travel expenses for on-site assembly supervision.

E. Pressure drop across the filter bank shall be minimum 1.5 in. w.g. and shall be included into the internal static pressure losses of the equipment.

F. Roof Top Units shall be shipped to the site in assembled sections based on shipping splits suitable for rigging at the site. Size of each piece shall be no greater than required for trucking or rigging (Refer to plans for more detail). The equipment supplier shall provide Factory Personnel to assist in assembly of the unit at the site. The Contractor shall prepare the site, including, but not limited to ductwork, ductwork accessories, piping, piping accessories, controls, roof flashing coordination and preparation, and leveling of steel before factory supervised assembly the air handling unit. Steel support frame is to be installed to tolerance of level and flatness required by unit manufacturer. RTU manufacturer to provide onsite assembly crew supervisor to assist with

G. Manufacturer shall refer to associated custom air handling unit drawings for additional details and requirements. Refer to Controls Schematic for additional device and conduit requirements.

1.4 QUALITY ASSURANCE

A. All equipment or components of this specification section shall meet or exceed the requirements and quality of the items herein specified or as denoted on the drawings and schedule.

B. Equipment furnished under this specification shall be in accordance with the following industry, association and government codes and standards, as applicable to their design, fabrication, assembly and testing.
1. AMCA 99 Standards. AMCA/ISO: All plenum fans shall be tested in accordance with AMCA or ISO standards for sound and performance.
2. ARI 430 Central Station Air Handling Units. ARI Compliance: Coil shall be rated in accordance with ARI standard 410 and bear the ARI seal.
3. NFPA 70 National Electric Code
4. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating System NFPA Compliance: Units and components shall be designed, fabricated and installed in compliance NFPA 90A.
5. NEMA or IP Compliance: All motors shall comply with applicable NEMA/IP standards.

C. Fans shall be rated in accordance with AMCA Standard 210 for performance and AMCA Standard 301 for sound and shall bear the AMCA seal. Motor shall meet requirements of NEMA, IEEE, ANSI, and NEC standard. Coils shall be rated in accordance with ARI Standard 410 and bear the ARI seal.

D. Equipment Listing:
1. UL Compliance: Electrical components used shall be listed and labeled by UL.
2. ETL Compliance: Complete unit shall be listed and labeled by ETL per standards ANSI/UL 1995 and CAN/CSA C22.2 #236-05.

1.5 ACTION SUBMITTALS

A. Submit shop drawings on air handling units. Submittal shall include all dimensional drawings with associated weights and breakdown details pertaining to shipping and rigging. Include all materials of construction as well as fabrication and connection details.
1. Information including equipment data sheets, schedules and sketches.
2. Equipment drawings showing dimensions, weights (shipping & operating), configuration, major component locations, access door locations, duct connection sizes and locations, and shipping split locations.

3. Materials of construction for housing and major components
4. Roof curbs product data.

B. Shop drawing to include plans and elevation detailing exact location of all components, access door locations with indicated swing direction, duct and piping connection sizes, shipping split locations and maintenance access clearance dimensions.
   1. Include cabinet material, metal thickness, finishes, insulation, and accessories.
   2. Casing insulation product data and performance ratings.
   3. Access door and access panel product data and performance ratings.
   4. Roofing product data and performance ratings.
   5. Louver product data and performance ratings.
   6. Paint product data and performance ratings
   7. Metal grating product data and performance ratings.

C. Provide information on all coordinated conduit routing and sizing as it pertains to coordination with electrical and control system.
   1. Provide complete electrical data information including wiring diagrams and accessories. Clearly indicate differentiation between factory and field wiring.
   2. Electrical product data and performance ratings.

D. Provide detailed performance of all components for comparison to all scheduled values including but not limited to following: Fan manufacturer and performance curves with operating points clearly indicated. All motor size and type information. Coil selections with sizing, rows, fin spacing, face velocity, air and fluid temperatures, flow rates, pressure drops and connection sizes. heat recovery components with performance characteristics. Filter type, sizing, efficiency, and pressure drop.
   1. Fans:
      a. Include certified fan-performance curves with system operating conditions indicated. For fans operating at variable speeds include curves in 10 percent speed increments starting at design speed down to minimum speed.
      b. Include fan-sound power ratings in all eight octave bands. Include inlet or outlet sound power levels to coincide with sound requirements indicated on Drawings.
      c. Include fan construction and accessories. Submit sufficient information to show product compliance with requirements indicated.
      d. Include dimensions and weight.
      e. Include motor ratings, electrical characteristics, and motor accessories.
   2. Vibration isolation product data with performance ratings. Uniquely identify and include information for each different isolator type and indicate for each air-handling unit where each isolator type is being used.
   3. Include certified coil-performance ratings with system operating conditions indicated. Product data to include: dimensions, dry and operating weight, volume of fluid contained, materials of construction, and performance ratings with system operating conditions indicated
   4. Dampers product data, including housings, linkages, and operators with performance ratings.
   5. Filters product data with performance characteristics.
   6. Hydronic pipe, valves, fittings, vents, strainers, and hydronic accessories product data.
   7. Pipe insulation and jacket product data.

E. Provide octave band sound power levels for intake, supply and return air connections as well as radiated sound levels from enclosure.

F. Provide all factory testing data with associated testing procedures.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
   1. Iinclude in emergency, operation, and maintenance manuals.
   2. Include list of all required service procedures and intervals.
   3. Include list of required replacement parts for maintenance.

B. Maintenance Material
   1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      a. Pre and Final Filters: One set(s) for each air-handling unit.
   2. Access Door Gaskets: Recessed into the door frame and do not get tread on
   3. Tool Kit: Manufacturer to provide a tool kit including special tools required for air-handling unit service.

1.7 COORDINATION

A. Coordinate sizes and locations of structural-steel support members, with actual equipment provided.

1.8 DELIVERY, STORAGE, HANDLING

A. Thoroughly clean equipment, components and subassemblies of water, dirt, debris, weld splatter, grease, oil and other foreign matter prior to shipment.

B. Unit to be prepped and completely sealed for protection during shipment.
   1. Seal all openings in unit casings with gasketed, thin gauge sheet metal closure sheets.
   2. Seal closures, caps and plugs dust-tight and moisture-tight.
   3. Protect pipe flanges with plywood coverings; protect pipe threads with plastic end caps or plugs.
   4. Protect machined surfaces with suitable, easily removable rust preventive.
   5. Provide full charge of proper lubricant for grease lubricated bearings.
   6. Provide desiccant bags or vapor phase inhibitors where required to keep components dry.

C. Ship all air handlers with complete protection from rain and dirt. Air handlers shipped on open trailers shall be protected with a minimum of two (2) layers of heavy mill shrink wrap plastic. Covering units with tarpaulins will not be acceptable since tarpaulins may damage the unit surface.

D. Units delivered with scratched, dented, or dirty surfaces or damage of any type shall be restored to “as new” condition as directed by the Architect/Engineer/Owner at no cost to Owner.

E. If equipment is to be stored before use, shipping protection provided by the unit manufacturer shall remain on the unit until the unit is installed. Manufacturer shall submit written recommendations for field storage.

F. Provide non-corrosive nameplate permanently attached to the equipment containing the following information:
   1. Manufacturer's project/serial number
   2. Plant name and location
   3. Customer equipment number
   4. Date of manufacture

G. Deliver air-handling units with factory-installed shipping skids and lifting lugs; pack small components in factory-fabricated protective containers. Cover units with heat-shrinkable plastic sheeting suitable for shipping from point of manufacture to Project.

H. Handle air-handling units carefully to avoid damage to components, casing, and finish. Do not install damaged components; replace and return damaged components to air-handling unit manufacturer.

I. Store air-handling units in a clean dry place and protect them from weather and construction activities.

J. Keep air-handling units fully covered and protected during construction. Remove dirt and debris and clean units to a factory-cleaned condition.

K. Comply with manufacturer's written rigging and installation instructions for unloading air-handling units and moving them to their final locations.

L. For air-handling units equipped with key locks on access doors, keep doors locked during construction.
   1. If access is required within air-handling units, only open the doors to sections that require access and lock doors at the end of each workday.
   2. Protect inside of air-handling units from damage and keep inside of units as clean as the factory-cleaned condition.
   3. Report observed abuse to Owner for immediate corrective action.

1.9 PERFORMANCE TESTING (FIELD TESTING)

A. The mechanical contractor shall include in their bid price, the cost associated with hiring a Testing and Balancing Contractor to test and document all performance parameters of the air handling unit at the time of start-up. The unit design cfm and static pressure shall be delivered at a brake horsepower within 2% of design conditions. Multiple point temperature readings shall be taken down stream of the mixing section to certify that temperatures do not vary by more than 10□F across the face of the heating coil assembly.

B. Air Handler manufacturer shall perform a casing leakage test shall be performed in the field after unit is fully assembled in place. The casing leakage test shall verify the unit casing leakage is less than .5% of the design airflow when tested at 1-1/2 times the design maximum static pressure. The unit shall be sealed with blank off plates over all duct connections, pressure sections shall be put under positive pressure, negative sections shall be put under negative pressure. The leakage shall be measured in each section using a calibrated orifice plate. The total casing leakage (positive plus negative) shall be considered the sum of the positive and negative leakage. Should the unit fail first test, the manufacturer will have an opportunity to make corrections. The corrections shall not inhibit the normal use of access doors and service panels.

C. Blank-off plates shall be furnished by the RTU vendor and field installed/removed by the contractor. Installing contractor shall provide assistance to perform the leakage test.

D. Failure to pass the leakage test will subject the air handling manufacturer to penalties based upon the total energy cost for the additional leakage over .5% at $8/CFM for a minimum operating period of ten years, or up the 10% of the air handling unit cost. The University may choose to accept the reduced value or require further modifications made and the unit be tested again.

E. All test reports shall submit the documented test results directly to the Engineer. This requirement for performance testing is in addition to the adjusting and balancing requirements associated with the HVAC Contract.

F. The Contractor shall assume all responsibility for equipment installation including field assembly of individual components or sections as required.

1.10 WARRANTY

A. All equipment, materials, and workmanship shall be warranted for (12) months from startup. During the warranty period, the manufacturer shall repair or replace, at no additional cost to the Owner, any equipment, material, or workmanship in which defects may develop.

B. The manufacturer to provide full one year parts and labor warranty after owner acceptance. The warranty labor to be performed by a factory authorized technician. Warranty work may be required after hours to accommodate owner requirements.

C. The manufacturer shall provide a corrosion warranty for the unit cabinet against general corrosion in the cabinet walls, floors, roof, doors, and fastening hardware.

PART 2 - PRODUCTS

2.1 REQUIREMENTS

A. Air handlers shall include the following minimum items in addition to those noted in the schedule or specified in this section.
   1. Roof Top Unit shall be of custom construction, fabricated of reinforced aluminum and braced with steel angle framework for maximum rigidity. The support mullions will be aluminum, not steel. Panels shall be insulated, heavy gauge double wall aluminum panels load bearing and capable of forming the enclosure without additional structural members. Panels shall be joined together with independent joining member and fastened with closed end aluminum rivets or stainless steel fasteners. Plated fasteners will not be accepted. A base rail shall be provided.
   2. Units with cooling coils shall have one continuous drain pan extending under the cooling coil sections. Drain pans are raised out of the unit base and not insulated. They are surrounded by air and thus will not condense: Each coil shall include a sloped, positive-draining stainless steel condensate pan assembly. Drain pan to be constructed from minimum 18 gauge 304 stainless steel material. Coils shall set above the condensate pan for ease of removal. Intermediate condensate drain pan shall be minimum 1-1/2” deep;

extending at least 3" upstream and at least 12" downstream of the coil face. Each drain pan shall be individually piped down to the bottom pan; lower drain pan to be provided with a drain connection of sufficient size to remove condensate extended to the unit exterior for connection by others.

3. Where the mixed air temperature in an air handling unit at the winter outdoor design temperature is less than 40 degrees F, freeze protection of the heating and cooling coils shall be provided. Coil freeze protection shall consist of run around pump.
   a. Provide hard wired freeze protection safety sensor
4. Air handling unit mixing box and outside/return air duct connections shall be configured to insure proper mixing and avoid stratification.
5. Air flow stations shall be provided to measure the
   a. Ventilation (outside) air flow
   b. Supply airflow
   c. Return airflow.
6. Water flow meters shall be provided to measure and trend heating and cooling water flow.
7. All air handling units shall have a minimum 24” access section, complete with operable doors, upstream of all coils, for cleaning and maintenance.
8. In general, air handling units shall be provided with MERV 8 pre-filter and MERV 14 final filter sections.
9. Vapor proof LED lights shall be provided inside each section of all units.
10. Exterior LED lights and GFCI outlets shall be provided on all outdoor units.

B. Provide air handling unit to fit intended use and in locations called for. Capacity, size arrangement, static pressure, brake horsepower, component parts and accessories as called for and as necessary to obtain required results and allow for proper maintenance. Guaranteed full capacity delivery through duct systems finally installed and under conditions listed. Guaranteed sound power level ratings not exceeding those of design equipment, or as scheduled.

C. All equipment shall be statically and dynamically balanced to acceptable tolerances with weights permanently fastened to fan blades, and components including the motor, installed on unit. Fan bearings shall be split pillow block and rated for L-10 life at 80,000 hours minimum.

D. Classification as designated by Unit Manufacturer based on minimum requirement listed below:

Total S.P.	Class
Up to 3 3/4 in. WG-STD	I
Up to 6-3/4 in. WG-STD	II
Up to 12-3/4 in. WG-STD	III

E. Motors: Furnished by equipment manufacturer. When VAV drives are used, the motors provided shall be matched to the adjustable speed drive selected for use. Motor to be suitable for use as a direct drive application and to be matched to fan to meet performance requirements. Provide with shaft grounding system.

F. Drives: Equipment supplier shall provide all direct drive fans. Belt driven fans are not acceptable.

G. Vibration Isolation:
1. Provide vibration isolation equipment for each fan supplied inside the air handling unit enclosures.
2. Fan and Motor mounted structural steel bases to be designed and manufactured by the fan supplier to ensure proper alignment of the fan and motor and structural integrity of the base to prevent vibration. The base shall include direct mount isolators, rubber type, 0.25-inch.

H. Fans: Fans shall be AMCA 210 certified for performance and rated in accordance with AMCA 300 for sound.

2.2 AIR HANDLING UNITS GENERAL

A. Custom built-up units shall be of the configuration, capacity and style as indicated on the drawings and Equipment Schedule and as specified herein. Through properly designed access; ease of maintenance, removability of components, and unit serviceability shall be assured.

B. The units shall be constructed for outdoor installation. Outdoor units to be provided with weatherproofing (roofing, guttering, etc.) as defined herein.

C. The units shall consist of: intake sections for return and outside air, mixing section with dampers for outside air, return air and exhaust air, pre-filter section, final filter section, heating coil section, cooling coil section, humidifier section, supply and return fan sections, diffuser section, and discharge section. Refer to unit configuration as shown on the drawings.
   1. Provide fan sections, filter sections, mixing box, plenums, coil sections, heat recovery components and other sections as called for and shown on the Contract Drawings.

D. Units shall be provided with a complete lighting system with switches and receptacles, damper operators furnished and installed on all dampers, and motor wiring to safety disconnect switches.

E. Unit shall employ aluminum material (panels, bases, supports, safing, etc.) to reduce overall unit weight and minimize facility maintenance requirements.

F. Provide safing between internal components and unit casing to prevent air bypass. Safing material shall match unit interior. All seams or voids between safing, components and unit casing shall be caulked and sealed airtight.

G. Provide hygienic unit design with interior suitable for washing down. The use of support members framed within the unit casing which will allow for trapping of debris between the supports and casing will not be allowed. Unit insulation must be completely encapsulated.

H. The unit is to be shipped factory assembled in one complete section, when possible. If necessary to ship the unit in sections, due to rigging or shipping constraints, the unit is to be designed to minimize the number of sections. The unit manufacturer shall field erect the units in place at the jobsite.

I. The unit sizes shown on drawings are established based on unit performance, structural, and access requirements and are not to be altered.

J. Gauges of metal and construction to be heavy enough to prevent vibration, undue noise or breathing. Unit to be of all aluminum construction.

K. Each coil shall be independently supported so that any one coil can be removed without removing another coil. Coil racks to be stainless steel or aluminum.

L. Outdoor units shall incorporate 6. In. deep extruded aluminum double drainable storm proof louvers with bird screens. Provide weather hood on intake louver to minimize wind driven snow ingestion.

M. Air and watertight sleeves, caulked and insulated where pipes and conduits penetrate unit casings.

N. All equipment within the air handling unit shall be provided with a minimum, 2" high base rail to raise equipment off the unit floor for housekeeping. Equipment mounted directly to the floor with fastener or drilled holes penetrating the water seal base is unacceptable.

O. Provide plug panels for removal of fans, motors, heat pipe and coils.

P. Any equipment flashing, internal partitions or other attachments to the casing shall be made in such a way as to ensure a permanent leak tight connection. Attachments that are bolted, screwed, or welded to or through the casing creating air bypass, air leakage or rust propagation area are not acceptable.

Q. Manufacturer responsible for installation membrane flashing between factory splits. All membrane for flashing provide by unit manufacturer.

R. Multiple section units shall be bolted together in the field using 304 stainless steel bolts, nuts and washers.

S. For outdoor units, provide 2" wide extruded aluminum gutter system and downspouts to roof level on length of exterior side of unit. Unit roof to slope to gutter. Gutter to slope 1/4 in. per foot.

T. Underside of the unit shall be fully insulated with minimum 1.5 in. thick foam insulation covered with .040 aluminum sheeting.

U. Operating weight limit of unit is 50 lbs. /sq. ft.

2.3 FAN SECTIONS:

A. Provide fans, motors and drives of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications.

B. Plenum Type:
   1. All fans shall be constructed to AMCA Standards and capacity shall be AMCA Standards 210-74 rated.
      a. Fan sections shall be complete with SWSI, arrangement.
      b. Fan shaft shall be solid 1040 or 1045 hot rolled steel that is turned, ground and polished.
      c. Fan unit shall be formed by welding heavy gauge steel inlet plate with spun inlet cones to steel angle frame.
      d. A square formed lip shall surround the unit, suitable for attachment of flex connector.
   2. Fan wheels shall be non-overloading, airfoil type.
      a. Impellers shall be statically and dynamically balanced to a level of G6.3 (per ANSI 2-19) or better.
      b. Hubs shall be straight bored, keyed and set screwed to the shaft.
      c. Shafts are to be solid steel sized for first critical speed of at least 1.25 times the maximum speed for the class for class I and II fans and 1.42 times the maximum speed for class for class III and IV fans.

3. Units to incorporate multiple fans with isolation dampers for independent operation in event of a fan failure.
    a. Provide heavy duty fan inlet isolation dampers on each fan capable of withstanding 6" s.p. when closed.
    b. Dampers shall be designed to withstand velocities up to 4,000 fpm. Isolation dampers to be Ruskin Model CD50 or equivalent.
4. The blades shall be aluminum airfoil design and shall be continuously welded to the wheel shroud and backplate.
    a. The fan shall be mounted in the horizontal position and shall be an Arrangement 4.
5. Panels and framework shall be constructed of heavy gauge, precision laser cut and die formed ASTM A-569 low carbon steel to provide a rigid structure to support the shaft and bearings and reduce low frequency vibration.
6. Provide guards meeting OSHA standards at fan inlet and to completely enclose fan wheel and rotating parts.
    a. Provide flexible connection between fan inlet and inlet wall.
    b. Provide dampened thrust restraints.
7. Fans shall have a factory full spectrum dynamic balance BV-3 for Class III.
8. Bearings are to be heavy duty, grease lubricated, anti-friction, self-aligning, pillow block type and selected for minimum average bearing life (AFBMA L-50) in excess of 200,000 hours at the maximum class RPM.
    a. All bearings shall be equipped with regreasable Zerk fittings and lubrication lines extended to accessible location on fan housing for easy access for lubrication.
9. Fan shall be provided with wire mesh protective wheel enclosure and heavy gauge wire inlet screen. In the event inlet vanes are provided, fan will not require inlet screens.
10. Fan shall be cleaned, prime coated and provided with two coats of enamel final coat.
11. Each fan shall be test run at their operating speed or at the maximum RPM for the particular fan's construction class prior to shipment.
    a. The fans are to be balanced and records maintained of the readings in the axial, vertical, and horizontal direction on each of the fan's bearings. Final peak velocity measurements shall not exceed 0.1 in/sec.
12. Provide overhead beam with trolley for removal of fan motor(s).
    a. Align with motor and access panel/door.
    b. Arrangement to allow for removal of fan motor and components through the supply section into service corridor or directly to roof through outside wall.
13. Provide all fans with Piezometer rings. Transmitters by control contractor
14. Acceptable dampers:
    a. Arrow 'AFD-20'
    b. Ruskin 'CD-50'
    c. TAMCO 1500.
15. Acceptable fan manufacturers
    a. Twin City Fan
    b. Greenheck
    c. Cook
    d. New York Blower

C. Motors
1. Shall be 1170 RPM, 460V/3ph/60Hz
2. Motor shall be premium efficient, ODP / TEFC enclosure.
3. Motor shall be of HP as listed on schedule and be selected for a minimum of 10% over calculated BHP. The motor service factor shall be a minimum of 1.15. (Substitute for arr. 4 direct-drive) Motor shall be of HP listed on schedule; selected to provide adequate torque

throughout entire range of fan operation and not exceed nameplate HP when fan operates at synchronous motor speed.

4. Motor shall be designed for continuous duty operation, NEMA Design B with class F insulation.
5. The motor shall be suitable for operating with variable frequency drives without undue noise, vibration or deterioration of reliability and life.
6. Motors shall be “Inverter Ready” per NEMA Std. MG1 part 31.4.4.2 and labeled as such.
7. Provide stainless steel nameplate indicating the following:
   a. NEMA efficiency index nominal efficient (MB1-12.53BO).
   b. AFBMA bearing numbers.
   c. Lubrication instructions.
8. Acceptable motor manufactures:
   a. Baldor
   b. Marathon Electric
   c. TECO – Westinghouse

D. The entire fan assembly shall be provided with a minimum of 18” clearance on all unattached sides for proper service access. Fan inlets to be provided with a minimum clearance distance equal to 75% of the wheel diameter.

E. The unit manufacturer shall provide flexible connection between fan and fan wall. Fan assembly shall be provided with thrust arrestors as required to prevent damage to the flex connection. Flex connection material shall be flame retardant fabric suitable for intended use meeting the requirements of NFPA 90A.

F. The fan and motor shall be factory-mounted on a spring type vibration base. The base shall be mounted on stable free standing spring isolators with 3” maximum deflection rating. Spring efficiency to be not less than 98%.

G. Fan section to be provided with structural I-beam assembly posted from the unit floor for mounting trolley to assist in motor removal; trolley assembly by others. Beam assembly to be steel construction; cleaned, prime coated and provided with two coats of enamel final coat.

H. All features, as outlined above shall be provided in order to reduce fan system maintenance downtime and minimize equipment service.

2.4 HEATING COIL SECTIONS:

A. Provide hot water heating coils of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of 550 fpm; maximum head pressure loss of 15 ft.

B. Provide hot water reheat heating coils of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of 550 fpm; maximum head pressure loss of 17 ft.

C. Non-ferrous heating coils, 125 psi working pressure, designed to relieve expansion and contraction strains. Minimum 16 gauge stainless steel casing, non- ferrous headers, 0.025” copper tubes with 0.035” thick "U" bends, 0.0075” aluminum fins, for coils. Coils tested at 300 psig then leak tested at 200 psig with air pressure under water. Hot water heating coils, serpentine type,

number rows and arrangement as called for; same end connections with vent chamber on return end and completely drainable.

D. Coils shall be individually supported by a rack system. This rack shall allow any one (1) coil to be removed through a plug panel, without disturbing any other coil. Coils stacked one on top of the other will not be accepted.

E. The supply and return connections are to be extended and sealed through the casing wall; drain and vent connections shall be piped within the unit with ball valves (Watts Model B6000 or equal) for draining and venting of each coil. Where split coils are utilized, all internal piping within the unit shall be provided by the unit manufacturer and extended to outside of unit casing.

F. Coils shall be circuited to provide the required performance; the use of internal restrictive devices, or turbulators, to obtain turbulent flow will not be acceptable.

G. Coils shall be tested to 250 psig under water and shall be guaranteed for 200 psig working pressure.

H. Acceptable coil manufacturers:
1. Heatcraft
2. Aerofin
3. Greenheck

2.5 CHILLED WATER COOLING:

A. Provide chilled water cooling coils of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of 500 fpm; maximum head pressure loss of 25 ft.

B. Copper tubes not less than 0.025” tube wall with 0.035” thick "U" bends; non- ferrous or cast iron headers. Plate type 0.0075” aluminum fins with expanded tube. Completely drainable and able to be vented. Circuited so as to keep head loss through coil not greater than called for. Minimum 16 gauge stainless steel casings. Fin spacing to meet conditions called for. Coils bottom supply, counterflow heat transfer. Provide with Turbulators, where required to achieve scheduled performance.

C. Coils shall be individually supported by a stainless steel rack system. This rack shall allow any one (1) coil to be removed through a plug panel, without disturbing any other coil. Coils stacked one on top of the other will not be accepted.

D. Coils shall be circuited to provide the required performance; the use of internal restrictive devices, or turbulators, to obtain turbulent flow will not be acceptable.

E. Each coil shall include a sloped, positive-draining stainless steel condensate pan assembly. Drain pan to be constructed from minimum 18 gauge 304 stainless steel material. Coils shall set above the condensate pan for ease of removal. Intermediate condensate drain pan shall be minimum 1-1/2” deep; extending at least 3" upstream and at least 12" downstream of the coil face. Each drain pan shall be individually piped down to the bottom pan; lower drain pan to be provided with a drain connection of sufficient size to remove condensate extended to the unit exterior for connection by others. Recessed drain pans are not acceptable.

F. Active cooling coil condensate drain connections to be a minimum 12 inches above the bottom of the air handling unit base for trapping.

G. Where necessary to prevent moisture carryover, each coil shall have aluminum or stainless steel moisture eliminators provided on the downstream side. Cooling coils condensate pans shall be designed and manufactured to incorporate future eliminators without any field modification.

H. Coils to be sized for max velocity as indicated in the schedule.

I. The supply and return connections are to be extended and sealed through the casing wall; drain and vent connections shall be piped within the unit with ball valves (Watts Model B6000 or equal) for draining and venting of each coil. Where split coils are utilized, all internal piping within the unit shall be provided by the unit manufacturer and extended to outside of unit casing.

J. Coils shall be tested to 250 psig under water and shall be guaranteed for 200 psig working pressure.

K. Provide removable access panels in the unit casing on each side of the unit for ease of coil removal.

L. Acceptable coil manufacturers:
1. Heatcraft
2. Aerofin
3. Greenheck

2.6 HEAT PIPE ENERGY RECOVERY:

A. Horizontal rack system with refrigerant filled 1/2 in. copper tubes with aluminum rifled fins. Stainless steel casings.

B. R410A

C. Fixed assembly with air tight seal between supply air stream and exhaust system with a foam filled double serpentine partition.

D. Pre-filter and bypass damper on both our streams.

E. Counter flow design.

F. Drain Pan: Pitch for positive drainage. Stainless steel pan construction.

G. Tested and rated AHRI certification.

H. Design Make: Innergytech

2.7 AIR HANDLING UNIT CASING:

A. Unit Casing
1. Double wall, insulated, air pressure tight, casing assemblies.

2. Aluminum panels with aluminum framing members.
3. All parts shall be aluminum, unless otherwise indicated elsewhere in this specification.
4. Where dissimilar metals are used they shall be dielectrically isolated to prevent galvanic action.
5. No through metal shall be allowed and shall be achieved with a minimum 3/8" thick epoxy bridge between metals.
6. Adhesive tapes or gaskets will not constitute an acceptable thermal brake.
7. Bolts and hardware shall be stainless steel.
8. Casing system shall be guaranteed to assure the owner that system capacity, performance, and cleanliness standards specified are not compromised. Leakage to be guaranteed at no more than 1/2% of the design volume at 1-1/2 times the design operating pressure or 30 CFM, whichever is greater.
9. All casing walls shall be of panel construction, including but not limited to the fan discharge walls, mixing section walls and divider wall to the access corridor.
10. Panel system shall incorporate an integral thermal break system downstream of cooling coil such that there is no through metal path between the interior and exterior surface of the unit casing at all locations.
    a. The thermal break shall consist of a minimum 1/2" structural epoxy bridge. Adhesive tapes or gaskets do not constitute an acceptable thermal break.
    b. Criteria to evaluate requirement for thermal break system shall be based upon scheduled unit performance and ambient conditions anticipated around the units.
11. Any equipment flashing, internal partitions or other attachments to the casing shall be made in such a way as to ensure a permanent leak-tight connection.
    a. Attachments that are bolted, screwed, or welded to or through the casing creating air bypass, air leakage or rust propagation areas are not acceptable.
12. All ductwork penetrations through unit enclosure shall be provided with framed openings of size and arrangement as indicated on drawing.
    a. Openings to be provided with flanged duct connections of same material as casing interior extending a minimum of 4" from surface of unit casing.
13. Pipe and conduit penetrations through the unit casings shall be provided by the unit manufacturer and be properly sealed prior to leaving the factory. Penetrations sealed by simply caulking around extension are not acceptable.

B. Unit Panels
1. Panels minimum 2-1/2 in. thick, with minimum 0.040 in. Stucco aluminum gauge solid exterior sheet and 0.040 in. gauge solid inside sheet.
2. Panels filled with 3-pcf high density polyisocyanurate foam insulation. The panel R value shall be a minimum of 12 or greater
3. Wall panels shall be continuously sealed (gasketed) between interior and exterior skin.
4. Spot welding or mechanical fasteners shall be on 6 in centers maximum.
5. The maximum allowable panel deflection is 1/200th of the panel span at the full rated unit static pressure.
6. Thermal brake and panel insulating coefficient shall be designed to guarantee that casing will not sweat with exterior conditions of 91Fdb/74Fwd and interior conditions of 55Fsat.
7. Interior space packed with blown foam.
8. Panel U-value shall not exceed 0.049 BTU/hr./sq.ft/°F. UL fire rating; flame spread - 10-20, fuel contributed - 1015, smoke developed - 0-20.
9. Each panel shall contain an integral frame or be properly supported by a structural framing system.
10. Panel shall have continuous tight seal at the interior and exterior skins completely encapsulating the insulation.

C. Service Access Doors
1. Access doors for serviced access between each section.
2. Door swing to be based on pressure differential direction of flow so that doors are pushed closed and not open when unlatched.
3. Removable access panels shall be provided for service and maintenance.
4. Access panels shall be of the same construction as panels described above.
5. Removable access panels shall be designed and constructed such that removal and replacement may be accomplished without disturbing adjacent panels.
6. Airtight integrity must be maintained.

D. Base Rails
1. Units to have aluminum channel base rail of sufficient depth for proper unit support.
   a. The unit shall be constructed on an all-aluminum or stainless steel structural base.
   b. The base shall be designed to distribute loads properly to a suitable mounting surface and be braced to support internal components without sagging, pulsating or oil canning.
2. Unit floor in air handling sections shall be 3/16" minimum thickness aluminum checker plate with continuous 2 inch raised lip at perimeter of unit and between sections and fully welded watertight (spot welding or threaded fasteners sealed watertight is not acceptable).
3. Provide individual drains in each section of the air handling unit extended to unit exterior base and (capped) for piping trap connections in the field.
4. All section or compartments of the unit shall be fully drainable.
5. The floor plate thickness and supports shall be sufficient to avoid any "tin canning" when 200 lb. point loading is applied to the flooring system.
6. Floor pan shall be foam insulated to prevent condensation and sealed with exterior aluminum skin.
7. Recessed inside of unit base for outdoor units. Skins fastened to bottom of unit support rails are not acceptable.
8. The base floor is to be supported with adequate stiffening members to prevent oil canning.
9. Caulking, gaskets and mechanical fasteners to guarantee seals and water tightness of joints will not be acceptable.
10. The perimeter support members shall be a minimum of 6” structural member properly sized to support all major components and the housing during rigging, handling and operation of the unit.
11. Each section of the unit base shall contain a minimum 1” NPT drain to facilitate system washdown, maintenance and condensate removal. Areas in the base where potential standing water cannot be removed through drains or weep holes are not acceptable. Clean out drains shall be provided with removable caps of non-corrosive material.
12. All equipment within air handling unit shall be provided with a minimum 2" high base to raise equipment off unit floor for housekeeping. Equipment mounted directly on unit floor is unacceptable.
13. Supply air openings to be framed with 2” high water dam continuously welded to the pan to allow proper duct connections and to prevent moisture from entering the openings. Framed openings shall be provided with removable aluminum or 304 stainless steel grating designed and fabricated for a live load of 100 pounds per square foot. Galvanized or painted steel grating will not be accepted.
14. All unit base service openings shall be framed with a minimum 2” high water dam continuously welded to the floor. All pipe and electric conduit chases with openings to building or elements shall be covered with thin gage aluminum or 304 stainless steel. Penetrations by contractors shall be sealed by the respective contractor.

15. Fastening to floor plate or joining of unit sections to be accomplished by bolting through gasketed joints above the floor line or continuously welding. Fasteners which penetrate base floor plate are not acceptable.
16. Unit to be provided with properly located permanent lifting plates or removable lifting lugs for each section to adequately allow rigging of the unit sections in place.

E. Door Panels
1. Constructed of same material and gauges as panels.
2. Minimum door size of 24 in., 2-1/2 in. thick of the overlapping seal type.
3. Doors shall be supplied with continuous non-pitching gaskets.
   a. The access doors shall incorporate two continuous separate gasket seals around the entire periphery of the door.
   b. Gasket material shall be UV-resistant, closed cell neoprene; gaskets shall be attached by adhesive and not mechanically held in place.
   c. Single gasket seals will not be accepted.
4. Doors to be supplied with stainless steel piano hinges.
   a. Each access door shall be mounted with a corrosion-resistant continuous piano hinge and shall have a least two (2) non-corrosive handles operable from either side.
5. Minimum of two cast aluminum or fiber reinforced plastic door latches with an inside release handle.
6. Doors shall be assembled with hinge hardware attached and adjusted in the field.
7. Door latches wedge lever type with handles inside and outside.
8. Hinges designed for door size and weight.
9. Doors installed to open against the air pressure.
10. Provide 1” dia. test ports with screwed caps on casing upstream and downstream of all coils and filters for pressure and temperature measurement.
11. Interior doors shall have 10 in. (min.) square thermal pane windows.
   a. Each access door shall contain a thermopane safety glass window (min. 10” square).
12. All doors serving fan sections or other rotating equipment shall be provided with lockable type hardware.
13. A door entering into rotating components of the air handling unit shall be provided with signage indicating “Do Not Enter – Rotating Machinery”.

F. Roof
1. Roof channels, aprons and corners joined of aluminum and formed to prevent a direct path for sound and/or air leakage.
2. Panel joiners 20 gauge minimum.
3. Where these roll formed joiner sections are not utilized, 16 gauge minimum.
4. Panel joiners and connectors shall allow for expansion.
5. Unit roofs for outdoor units
   a. Sloped a minimum of 1/4” per foot to assure positive run-off.
   b. Roof to peak in center and drain off to both sides / on door side and drain away from door side.
   c. The entire roofing system shall be a polymer membrane permanently bonded to the unit roof.
   d. Membrane to be minimum 0.045” thick.
   e. Standing seam roofing system will not be acceptable.
   f. Unit shall be provided with a non-corrosive rain gutter system with downspouts to guide unit roof water run-off to the building roof.
   g. Units incorporating roof systems without controlled water run-off accommodations are not acceptable.

G. Framed Openings
1. Provide framed openings fittings with curved bell mouth fittings.
2. Bell mouth fittings shall have a minimum smooth radius equal to 20% of the diameter or shortest side (rectangular) to provide optimum performance.
3. Unless otherwise noted on drawings.

H. Structural System
1. The structure shall be fully self-supporting.
2. Where roof spans and wall loadings require additional structural strength, it shall be furnished either by heavier roof and wall joiners, or, additional structural members capable of withstanding a differential pressure of 10 in. w.g.
3. Unit built on unpainted aluminum base channel.

2.8 OUTSIDE AIR SECTION

A. Outside air shall be admitted and exhaust air shall be discharged through storm-proof, extruded aluminum or stainless steel louvers, minimum 3-1/2” deep with aluminum or stainless steel birdscreen and aluminum or stainless steel weather hoods. Weatherhood exterior to match the finish of the unit casing.

B. Outside air shall be admitted through drainable blade stationary fog-type louver. Louver shall be certified storm-proof, extruded aluminum, with aluminum birdscreen. Louver to be Cesco Products, Type ASL6.

C. Louver shall have AMCA certified air performance and water penetration ratings.

D. Louver to be provided with a low-leakage outside air damper. Dampers shall be as specified below and shall be furnished and installed by the unit manufacturer.

E. Outside air intake shall be sized for a maximum of 450 fpm. Exhaust air discharge shall be sized for a maximum of 750 fpm.

2.9 FILTER SECTIONS:

A. Provide all prefilters and final filters of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Filters to be selected for a maximum face velocity of 500 fpm.

B. Filters shall have nominal rating of 500 fpm. Each cell shall be 24" x 24", or 12” x 24”. Initial pressure drop shall not exceed that indicated. Media shall be approved and listed as Underwriters Laboratories Class 2 when tested according to UL Standard 900 and as described below:
1. Prefilters: 2" thick MERV 8 efficiency (per ASHRAE Test Standard 52.2-2007), and MERV 12 (per ASHRAE Test Standard 52.2-2007), rigid disposable filters.
2. Final Filters: 12” rigid type, MERV 14 (per ASHRAE Test Standard 52.2-2007), rigid disposable filters.

C. Factory install all filter holding frames in support racking by bolting or riveting. Seal between all filter frames. Provide all required holding clips. Include mounting rack for

1. Filter frames to be 304 stainless steel.
2. Filter banks shall be reinforced with vertical stiffeners to assure rigidity, and providing flashing between filter banks and unit casings to air leakage or bypass around the frames.
3. Provide mounting rack as indicated on drawing and specified.

D. Filters shall be upstream removable. Side access is not acceptable. Pre-filter sections shall be complete with holding frames capable of holding prefilters with high efficiency filters. Prefilters shall be capable of being removed and installed without affecting seal of the high efficiency filter.

E. Filter holding frames shall be installed and individually sealed to prevent leakage around frames. Filter banks shall be reinforced with vertical stiffeners to assure rigidity. Unit manufacturer shall provide flashing between filter banks and unit casings to prevent air leakage or bypass around the frames. Installation techniques, sealing methods, and structural reinforcement eliminate unfiltered air bypass and assure system cleanliness based on filter efficiencies specified.

F. Unit manufacturer shall provide and install a Dwyer series 2000 magnehelic gauge complete with stainless steel static pressure tips and accessories for indicating the operating pressure drop of each filter bank.
1. Indicating range of gauge shall be selected at two times the final resistance of the filter bank.
2. Gauge to be 3-7/8 in. diameter white dial diaphragm actuated.
3. Guaranteed accurate to + 2% of full scale.
4. Pointer zero adjustment.
5. Provide all accessories including adapters, mounting panel, pressure tips, fittings, tubing, vent valves.

G. Provide access doors for replacing filters and access to dampers.

H. Acceptable filter frame and filter manufacturers:
1. American Air Filter
2. Farr

I. Provide one complete extra full set of filters.

2.10 MIXING SECTION

A. Complete with framed openings with low-leakage outside and return air dampers. Dampers shall be as specified below and shall be furnished and installed by the unit manufacturer.

B. Mixing section shall be designed for controlled mixing in that the proximity, relation, and air velocity for each respective damper shall be such that volume swings and stratification will be eliminated.

C. Outside air damper banks incorporating minimum outside air to be provided with an independent damper with independent control for minimum outside air. Minimum outside air provided by controlling outside air damper bank to a minimum position will not be acceptable.

2.11 DAMPERS

A. Return, Exhaust, Bypass, Fan isolation and Outside Air Damper:
   1. Dampers shall be low leakage, opposed blade design capable of withstanding 8” wg differential pressure at 2,000 fpm approach velocity.
   2. Leakage rate not to exceed 6 CFM per ft.2 at 4” wg differential pressure and 2,000 fpm approach velocity.
   3. Dampers shall be opposed blade, unless otherwise noted on drawings, aluminum, airfoil, and low leakage type design.

B. Damper frames shall be made of extruded aluminum.
   1. Damper blades shall be extruded aluminum airfoil shape to withstand high velocities and static pressures.
   2. Dampers shall be provided with stainless steel blade end seals and flexible synthetic blade edge seals.
   3. Blade and frame seals shall be of extruded silicone.
   4. Seals are to be secured in an integral slot with the aluminum extrusions.

C. Bearings shall be composed of a Celcon inner bearing fixed to an aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to- plastic contact.

D. Linkage hardware shall be installed in the frame side and constructed of aluminum and corrosion-resistant, zinc-plated steel, complete with cup- point trunnion screws for a slip-proof grip.

E. Dampers are to be designed for operation in temperatures ranging between -40°F and 212°F.

F. All dampers shall be arranged within the air-handling unit to allow the actuators to be installed within the enclosure of the units and not mounted at the unit exterior unless otherwise noted on drawings. All dampers to be surface mounted to allow for direct connection of actuators on drive shaft.

G. Unit(s) shall include separate minimum outside air dampers where shown on drawings. Minimum outside air opening shall be sized and arranged to accommodate outside airflow measurement station.

H. Where multiple dampers are installed end to end, satisfactory clearance shall be maintained between linkages to allow for actuator linkage connections. Actuation linkage not to be attached to face of damper. Minimum damper blade width shall be 6".

I. Damper actuators to be mounted by unit manufacturer.
   1. Damper actuator to be supplied by control contractor and mounted in the factory.
   2. Actuators for dampers with modulating control to be provided with pilot positioners.

J. Equipment Manufacturers
   1. Basis of Design Equipment: Ruskin ‘CD-50’
   2. Acceptable Makes:
      a. Arrow ‘AFD-20’
      b. TAMCO 1500
      c. Greenheck.

2.12 UNIT DISCHARGE SECTION

A. Discharge section with exit velocities exceeding 2000 fpm shall be complete with aerodynamically designed framed discharge openings or spun bellmouth fittings in order to reduce overall system static pressures.

B. Bellmouth fittings shall have minimum radius equal to 20% of the diameter (round or oval) or shortest side (rectangular) to provide optimum performance. Bellmouths with radius less than 2" are not acceptable. Bellmouth to be mounted flush with unit interior edge to minimize exit loss.

C. Openings shall conform to the size and configuration of the ductwork where shown.

D. Smoke DETECTOR shall be furnished and installed by the unit manufacturer for supply air and return air openings as shown on the drawings.

2.13 UNIT RETURN SECTION

A. Return section with ilet velocities exceeding 2000 fpm shall be complete with aerodynamically designed framed discharge openings or spun bellmouth fittings in order to reduce overall system static pressures.

B. Bellmouth fittings shall have minimum radius equal to 20% of the diameter (round or oval) or shortest side (rectangular) to provide optimum performance. Bellmouths with radius less than 2" are not acceptable. Bellmouth to be mounted flush with unit interior edge to minimize exit loss.

C. Openings shall conform to the size and configuration of the ductwork where shown.

D. Smoke DETECTOR shall be furnished and installed by the unit manufacturer for return air and return air openings as shown on the drawings.

2.14 SERVICE CORRIDOR FOR OUTDOOR UNITS

A. Outdoor Unit to be provided with an integral service vestibule Access corridor to be minimum five (5) ft. clear wide by full height and length of the unit. Access corridor to be of the same construction as the unit previously described. Access corridor floor shall be level without obstructions such as at joining sections that might act as trip points.

B. Provide Qty. two - 5KW 3/60/460V electric unit heater with wall mounted thermostat for maintaining a minimum of 50°F temperature during winter operation. Provide factory mounted and wired heater, disconnect switch and thermostat. Provide ventilation for removing heat of variable speed drives and other devices within the vestibule.

C. The service corridor shall provide for supporting of field piping installations. The support structure shall include a means for pipe hangers to be attached to supporting members. The support members shall be sized to support a uniform piping load of 250 lbs./ft.

2.15 ELECTRICAL

A. All electrical work shall be installed in full compliance with the National Electric Code, and all local codes and requirements. Where applicable, components shall be UL approved. All wiring and components inside air handling plenums shall be weatherproof and rated for such use. All equipment shall contain a grounding conductor.
   1. WIRING: 600 volt rated, type #12 THHN copper (minimum size).
   2. CONDUIT: EMT Aluminum rigid conduit utilizing compression type fittings. All conduit penetrations in the unit housing and penetrations across the cooling coil sections and humidifier sections shall be internally sealed with foam sealant to prevent the migration of water vapor in the conduit.

B. The Mechanical Contractor shall hire an electrical contractor to be responsible for mounting and wiring the all of devices on the air handler as detailed in the contract documents. The required installation labor, conduit, wiring, and miscellaneous fittings shall be provided by the electrical contractor. All internal conduit to be aluminum.

C. Unit manufacturer shall furnish, install and wire (factory or field) a complete lighting system to one (1) identified 120 volt feed location. Lighting system to include light fixtures, switches, and a GFCI receptacle per the following:
   1. LIGHT FIXTURES: vapor tight incandescent marine type guarded service light fixture, LED lamp for each section of the units. Each access section to be provided with minimum of one (1) light fixture. Fan sections and filter sections to be provided with minimum of two (2) light fixtures. Access corridors to have a minimum of three (3) light fixtures.
   2. LIGHT SWITCHES: 20 AMP, single pole, specification grade, toggle switch in lug type device box with stainless steel weatherproof cover.
   3. GFCI CONVENIENCE OUTLETS: 20 AMP, specification grade, NEMA 5-20R, duplex receptacle in lug type device box with stainless steel weatherproof cover. Unit to be provided with four (4) convenience outlet. One (1) on unit exterior at the fan section and three (3) in the service corridor section.

D. Unit manufacturer shall furnish , install and wire (factory or field) a safety switch / fan motor disconnect for each fan motor to one (1) identified 460 volt feed location. Final connection to motors shall be made through Sealtight flexible conduit.
   1. FAN MOTOR DISCONNECTS: 3 pole, 600V, horsepower rated, heavy duty, visible blade, non-fused, NEMA 3R or 4 safety switch with 2 pole control circuit interlock if used in conjunction with variable speed drive.
   2. Provided with the VFD.

E. Field wire unit on site to include power for fans, lights, VFD, general power and controls.

2.16 SMOKE DETECTOR

A. Smoke Detector: Field furnish and install Smoke detector shall be listed for Building fire alarm systems. Refer to section 283111 Digital, Addressable Fire-Alarm System.

2.17 ACCESSORIES:

A. All mounting of conduit shall be factory mounted by the unit manufacturer, field by the mechanical contractor. This includes all internal power and field installed control wiring within unit. All through wall penetrations, sealing sleeves and junction boxes are to be provided by unit manufacturer. All internal wiring shall be pulled through installed conduit in the field as part of the Contractor's work. All fans and lighting circuits are to be wired to junction box on exterior of unit for a single point power connection to each by Contractor. All internal conduit to be aluminum. Any additional conduit required in the field shall be coordinated with factory for mounting and location restrictions.

B. Provide internal industrial grade moisture proof lighting within each section of the unit that has an access door. Lighting shall be wired back to timer switch, each section shall include a light and timer switch. The lighting shall be LED vapor tight fixtures.

C. All fans shall be field wired to a junction box mounted in service corridor. Installation of all wiring and conduit shall be in conformance with NEC. (Coordinate with single point power, VFDs, multiple feeds)

D. Provide a minimum of four (4) 3/4 inch diameter pipe penetrations, air tight, with threaded connections through the exterior and interior of unit for field use by the Installation Contractor. The pipe penetrations shall be spaced evenly along the length of the unit and shall be located on the same side as the access doors. The pipe penetrations shall be located 1'-0" down from the top of the air handling unit enclosure. Coordinate with Controls Contractor.

E. Provide in all units, in each fan section, an overhead telescoping beam with trolley for fan motor removal/replacements for a fan motors over 15HP.

2.18 AIR FLOW STATIONS:

A. Provide airflow measurement provision and transmitters for the purpose of continuously monitoring unit airflow volume.

B. Provide airflow measuring devices at the AHU supply, return, exhaust, minimum outside air, and economizer outdoor air sections. Airflow measuring device should be capable of measuring the entire airflow range.
   1. Fan airflows shall be measured with direct measurement at the fan inlets. All other locations shall be achieved with duct mounted airflow stations.

C. The airflow measurement system shall consist of a piezometric flow ring incorporated into the inlet of the fans. Ring shall consist of a minimum of four orifice ports strategically located in the throat of the fan inlet; orifice taps to be piped with tubing in a continuous ring. Tubing to be extended to accessible location for connection to flow transmitter.

D. Fans to be provided with piezo rings Piezometric ring to be provided integral with the fan construction.

E. BMS contractor to provide all transmitters and OA flow stations.

F. Provide mounting brackets for all electrical panels, control panel enclosures and adjustable speed drives as indicated on control drawings. All locations to be coordinated with installing contractors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. After completing the installation, inspect the air handler for damage, dirt or debris. Remove all dirt, construction debris and repair any damage to the finish including chips, scratches or dents.

B. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

C. Examine air-handling units before installation. Reject units with physical damage, and air-handling unit components that are wet, moisture damaged, or mold damaged.

D. Examine roughing-in for the following before installation of air-handling units:
   1. Structural substrate mounting and anchorage to verify actual sizes, types, and locations.
   2. Piping systems to verify actual sizes, types, and locations of connections.
   3. Ductwork and plenums to verify actual sizes, types, and locations of connections.
   4. Electrical services and controls to verify actual sizes, types, and locations of connections.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

F. Replace the filters used during the construction phase

3.2 INSTALLATION

A. The RTU shall be Assembled in the field by the Mechanical Contractor. The Mechanical Contractor shall provide all trades required to achieve a complete assembly including but not limited to Power and controls. Mechanical Contractor shall obtain he services of qualified licenses tradesmen to complete the field power and control installation for this unit.

B. Install unit per manufacturer’s recommendations and instructions as described in the Installation, Operation and Maintenance (IOM) manual.

C. Prior to the installation of the RTU, the mounting surface shall be confirmed smooth and level to a tolerance of ¼” over the air handler length. All existing mounting surfaces shall be repaired and/or sealed as required.

D. The installing contractor shall mount the Roof Top Unit using necessary base shims to assure a level installation and proper air handler operation.

E. Contractor shall NOT use the units to provide temporary heating, cooling or ventilation to the building during construction. 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.

F. Equipment Mounting: Install air-handling units at locations indicated on Drawings. Unless, otherwise indicated on Drawings, install air-handling units on concrete equipment bases.
   1. Install air-handling units on curbs following air-handling unit manufacturer's written procedures.

a. Install gaskets before setting air-handling units on curbs.
b. Secure air-handling units to curbs using stainless steel fasteners.
c. Install curb and fasten to structure.
d. Coordinate curb requirements, attachment, and location before installation.

G. 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.

H. Roof Openings:
1. Provide exact size and location of roof openings to trade installing structural framing and roof structure.
2. Supervise framing of openings to ensure coordinated installation with air-handling units.

I. Equipment Clearances and Access:
1. Arrange installation of air-handling units to provide access space around air-handling units for service and maintenance and for removal and replacement of internal components.
2. Provide clearance and access required by governing codes and NFPA 70.
3. At a minimum, comply with requirements indicated on Drawings and air-handling unit manufacturer's written instructions.

3.3 LIFTING INSTRUCTIONS

A. Performance air handlers must be rigged, lifted, and installed in strict accordance with the Installation, Operation, and Maintenance manual for air handlers. The units are also to be installed in strict accordance with the specifications.

B. Units shall be shipped on an integral 6" base frame for the purpose of mounting units to a housekeeping pad and providing additional height to properly trap condensate from the unit.

C. Each indoor unit section to be shipped with 4 lifting lugs for proper lift and installation. Indoor to also be shipped with a shipping skid designed for forklift transport.

D. Per ASHRAE 62.1 recommendation, indoor air handling units to be shipped stretch-wrapped to protect unit from in-transit rain and debris.

E. Installing contractor is responsible for long term storage in accordance with the Installation, Operation, and Maintenance manual.

3.4 PROTECTION DURING CONSTRUCTION

A. Exterior Covers: Cover air-handling units during construction with sealed covers to protect air-handling unit casing and externally mounted components from physical damage, dirt, dust and debris, paint splatter, and any other construction materials.
1. Minor physical damage, as determined by Owner, shall be repaired by air-handling unit factory service personnel to factory-finished condition.
2. Replace air-handling units with damage that in any way compromises the performance indicated.

B. Internal Access: Keep access doors locked to maximum extent possible and restrict access to only authorized personnel.
   1. Open access doors only during periods authorized work inside air-handling units is required.
   2. Coordinate and monitor work inside air-handling units on a shift basis. Lock access doors once work is complete or at the end of each shift.
   3. Immediately report unauthorized access and any observed damage to Owner.

3.5 DUCT CONNECTIONS

A. Connect ducts and plenums to air-handling unit connections. Comply with requirements in Section 233113 "Metal Ducts."

B. Connect ducts and plenums to air-handling unit connections with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

C. Provide duct transitions required to make field connections to air-handling units.

D. Arrange ducts and plenums to provide unobstructed access to inside of air-handling units.

3.6 PIPING CONNECTIONS

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

B. Where installing piping adjacent to air-handling unit, provide unobstructed access to inside of air-handling units for service and maintenance.

C. Connect piping to air-handling units with flexible connectors.

D. Drain Pan Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
   1. Make connections to air-handling unit connections with flanges .
   2. Extend dedicated drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
   3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
   4. Coordinate piping arrangements to allow access to traps in condensate drain below AHU floors.
   5. Install threaded cleanouts at changes in direction.
   6. Secure drain piping to structure.

E. Chilled-and Hot-Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
   1. Comply with requirements indicated on Drawings.
   2. Make connections to coils with a flange.
   3. Connect to each coil inlet with shutoff valve, test plug, pressure gauge, and thermometer.
   4. Connect to each coil outlet with balancing valve, test plug, pressure gauge thermometer, flow meter, and shutoff valve.

5. Connect each coil drain connection with a drain valve, which is full size of drain connection. Connect drain pipe to drain valve with union, and extend drain pipe to connect to storm drain system.
6. Connect each coil vent connection with manual vent, which is full size of vent connection.

3.7 ELECTRICAL CONNECTIONS

A. RTU shall be assembled on site and all electrical work shall be field wire by the Mechanical Contractor. Mechanical Contractor shall obtain the services of a License Electrical Contractor to wire the units in the field as it is being erected.

B. Install field power to each air-handling unit electrical power connection. Coordinate with air-handling unit manufacturer and installers.

C. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

E. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

F. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.8 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.

D. Smoke Detector
1. Where duct mounted smoke detectors are required by the 2020 New York State Uniform Fire Prevention and Building Code, and noted in this specification, the preference is to have the device factory mounted and provided as part of an assembly.

3.9 STARTUP SERVICE

A. Engage an air-handling unit factory-authorized service representative to perform startup service.
1. Complete installation and startup checks in accordance with 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, controls, 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 face-and-bypass dampers provide full face flow.
7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
8. Comb coil fins for parallel orientation.
9. Verify that proper thermal-overload protection is installed for electric heaters.
10. Install new, clean filters.
11. 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.

3.10 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

C. Before turning equipment over to Owner for use, adjust air-handling unit components that require further adjustment for proper operation. Consult air-handling unit manufacturer for instruction.

D. Occupancy Adjustments: When requested within [12] <Insert number> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two] <Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

E. Seasonal Adjustments: Make seasonal visits during warranty period to inspect and review operation of equipment. Make necessary adjustments for components observed to require adjustments for proper operation. Prepare and submit a report to Owner documenting each visit, observations, and any adjustments made.

3.11 FIELD CLEANING

A. Cleaning Schedule: After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and

immediately before Owner use, clean air-handling units to remove foreign material and construction dirt and dust.

B. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.
   1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
   2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
   3. Clean all internal components, such as, coils, dampers, filter frames, fans, and motors.
   4. Clean light fixtures and control devices.

C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.

D. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.

E. Acceptance: Following unit cleaning submit a written request for review and Owner acceptance. Acceptance for cleaning of air-handling units must pass a white glove test.

3.12 FIELD QUALITY CONTROL

A. After the equipment is installed, the manufacturer’s representative shall inspect the installation and recommend any corrective actions. Do not startup the equipment until the following operations are completed:
   1. Power is connected to the unit.
   2. Shipping materials have been removed.
   3. Filtration media is installed and clean.
   4. Piping and duct connections are installed and operational.
   5. Leak checks are completed on all water connections.
   6. All wiring, gasketing and hardware are properly installed on any multiple section units.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
   1. After field piping connections are complete, test hydronic coils and connections for leaks.
   2. Charge refrigerant coils with refrigerant and test for leaks.
   3. Field-Assembly Supervision: Instruct Installer and supervise field installation of first air-handling unit(s) shipped in multiple pieces for field assembly.
   4. Roof-Mounted Field-Installation Supervision: Instruct Installer and supervise field installation of first roof-mounted air-handling unit(s).
   5. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Field Casing Leakage Test:
   1. Perform leak testing of air-handling units that include field assembly of multiple sections. Air-handling units that are shipped and installed as a single piece do not require field testing.
   2. Leak test one air-handling unit(s) of each unique size and arrangement randomly selected by Commissioning Agent.
   3. Follow procedures complying with ASHRAE 111.
   4. Assembled air-handling units shall satisfy leakage criteria indicated. Modify air-handling units that fail to satisfy criteria and retest. For every air-handling unit that fails test, another air-handling unit shall be tested until all air-handling units tested pass leakage criteria on first attempt.
   5. Submit a test report for each test indicating test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.
   6. Test report shall be in accordance with ASHRAE 111.
   7. Witness Testing:
      a. Provide written notification at least 30 business days in advance of testing.
      b. Testing shall be conducted in presence of testing and balancing agent.
      c. Other parties such as Architect, Commissioning Agent, and Owner shall be invited to witness testing with attendance being optional.

F. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

G. Prepare test and inspection reports.

3.13 OPERATION DURING CONSTRUCTION

A. Operation of air-handling units for temporary cooling, heating, and ventilation is **not allowed without Owner authorization.**
   1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:
      a. Description of construction activities while units are operating.
      b. Operation:
         1) Beginning and ending calendar dates.
         2) List each day during week.
         3) List start and stop time and hours for each day.
      c. Startup procedures and shut-down procedures.
      d. Provisions for routine monitoring of unit operation.
      e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage and current and electrical fault.
      f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
      g. Record keeping.
   2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least [two] <Insert number> years after the warranty indicated expires.
   3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner.

B. Filtration During Temporary Use:
   1. Protect air-handling system ducts (exhaust air, outdoor air, and return air) with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 13 in accordance with ASHRAE 52.2.
   2. Protect air-handling units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and by-pass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 8 in accordance with ASHRAE 52.2.
   3. Do not operate air-handling units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
   4. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting and balancing.

C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.14 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 outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
   7. Comb coil fins for parallel orientation.
   8. Install new, clean filters.
   9. 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.
   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.

3.15 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing

3.16 DEMONSTRATION

A. Engage air-handling unit manufacturer factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

B. Training shall include, but not be limited to, procedures and schedules related to performance, safety, startup and shut down, troubleshooting, servicing, preventive maintenance, and how to obtain replacement parts.
   1. Access Doors: Adjustment, gasket removal and replacement, handle removal and replacement, and spare parts.
   2. Access Panels: Removal and replacement, adjustment, gasket removal and replacement, and spare parts.
   3. Air Blenders: Cleaning, operation, removal, and replacement.
   4. Coils: Cleaning, combing fins, draining, venting, removal, and replacement.
   5. Controls: Calibration, cleaning, operation, service, removal and replacement, and spare parts.
   6. Damper Assemblies: Cleaning, operation, service, removal and replacement, and spare parts.
   7. Drain Pans: Cleaning, removal, and replacement.
   8. Fan and Motor Assemblies: Cleaning, operation, removal and replacement, service, and spare parts.
   9. Filters: Operation, removal and replacement, frame gasket removal and replacement, clip removal and replacement, and spare parts.
   10. Lights, Receptacles and Switches: Cleaning, operation, service, removal and replacement, and spare parts.

C. Instructor:
   1. Instructor shall be factory trained and certified by air-handling unit manufacturer with current training on equipment installed.
   2. Instructor's credentials shall be submitted for review by Commissioning Agent[before scheduling training.
   3. Instructor(s) primary job responsibility shall be Owner training.
   4. Instructor(s) shall have not less than three years of training experience with air-handling unit manufacturer and past training experience on at least three projects of comparable size and complexity.

D. Schedule and Duration:
   1. Schedule training with Owner at least 20 business days before first training session.
   2. Training shall occur before Owner occupancy.
   3. Training shall be held at mutually agreed date and time during normal business hours.
   4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for a one-hour lunch period and 15-minute break after every two hours of training.
   5. The following training shall be accomplished after the completion
      a. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
      b. Provide a total of eight (8) hours of instruction at the site, during start-up.

c. Provide six (6) hours of instruction at the site after start-up
   1) Provide two (2) hours at three (3) months after start-up training
   2) Provide two (2) hour at six (6) months after start-up training.
   3) Provide two (2) hour at nine (9) months after start-up training

E. Location: Owner to provide a suitable on-site location to host classroom training.

F. Training Attendees: Assume three people.

G. Training Attendance Records: For record purposes, document training attendees at start of each new training session. Record date, time, brief description of training covered during the session, attendee's name, signature, phone number, and e-mail address. Submit scanned copy of sign-in sheet to Owner for each training session.

H. Training Format: Individual training modules to include classroom training followed by hands-on field demonstration and training.

I. Training Materials: Provide training materials in electronic format to each attendee.
   1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.

J. Training Video Recording: Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.

K. Written Acceptance: Obtain Commissioning Agent written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 237343.19

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Split-system air-conditioners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units 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. Filters: One set(s) for each air-handling unit.
   2. Gaskets: One set(s) for each access door.
   3. Fan Belts: One set(s) for each air-handling unit fan.

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. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period:
      a. For Compressor: One year(s) from date of Substantial Completion.
      b. For Parts: One year(s) from date of Substantial Completion.
      c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SPLIT-SYSTEM AIR-CONDITIONERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carrier Global Corporation.
   2. Daikin Applied.
   3. LG Electronics USA, Inc.; LG Electronics Inc.
   4. Mitsubishi Electric & Electronics USA, Inc.
   5. Samsung HVAC.
   6. Trane Inc.

B. Indoor Units (5 tons (18 kW) or Less):
   1. Concealed Evaporator-Fan Components:
      a. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
      b. Insulation: Faced, glass-fiber duct liner.

c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
d. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
e. Fan Motors:
    1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230500 "Common Work Results for HVAC."
    2) Multitapped, multispeed with internal thermal protection and permanent lubrication.
    3) Wiring Terminations: Connect motor to chassis wiring with plug connection.
f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
g. Filters: Permanent, cleanable.
h. Condensate Drain Pans:
    1) 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 humidifiers, and to direct water toward drain connection.
    2) Single-wall, galvanized-steel sheet.
    3) Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
        a) Minimum Connection Size: NPS 1
    4) Pan-Top Surface Coating: Asphaltic waterproofing compound.

C. Outdoor Units (5 tons (18 kW) or Less:
1. Air-Cooled, Compressor-Condenser Components:
    a. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
    b. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
        1) Compressor Type: Scroll.
        2) Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
        3) Refrigerant: R-410A.
        4) Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
    c. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
    d. Fan: Aluminum-propeller type, directly connected to motor.
    e. Motor: Permanently lubricated, with integral thermal-overload protection.
    f. Low Ambient Kit: Permits operation down to 45 deg F.
    g. Mounting Base: Polyethylene.

D. Accessories
1. Thermostat:

a. Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
   1) Compressor time delay.
   2) 24-hour time control of system stop and start.
   3) Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
   4) Fan-speed selection including auto setting.

2. Automatic-reset timer to prevent rapid cycling of compressor.
3. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
4. Drain Hose: For condensate.
5. Condensate pump

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify support for condensing unit is ready for unit installation.

B. Provide unit manufacturers recommended hangers and supports.

3.2 INSTALLATION – EVAPORATOR SECTION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install condensate piping with trap and route from drain pan to the janitors sink as indicated on the drawings.

D. Install components furnished loose for field mounting.

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

F. Installing contractor shall coordinate all BAS/BMS control requirements and connections with controls contractor.

3.3 INSTALLATION - CONDENSING UNIT

A. Install units on support as indicated on drawings.

B. Install units level and plumb.

C. Install refrigerant piping from unit to condensing unit. Install refrigerant specialties furnished with unit. Refer to Section 23 23 00.

D. Evacuate refrigerant piping and install initial charge of refrigerant.

E. Install electrical devices furnished loose for field mounting.

F. Install control wiring between indoor unit and condensing unit, and field installed accessories.

G. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

H. Provide 120V receptacle at each condensing unit.

3.4 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:
1. Install outdoor unit with prefabricated wall bracket.

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.5 CONNECTIONS

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

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

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. 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, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.7 EQUIPMENT INSTALLATION, GENERAL

A. Clearance:
1. Maintain manufacturer's recommended clearances for service and maintenance.
2. Maintain clearances required by governing code.

B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.
1. Loose components shall be installed by manufacturer’s service representative.

C. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.8 INSTALLATION OF INDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.

C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.

D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.

E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.

F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.

G. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch.

H. Attachment: Install hardware for proper attachment to supported equipment.

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

3.9 INSTALLATION OF OUTDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Install outdoor units on support structures indicated on Drawings.

C. Install wind restraints attachments for all outdoor units to their support frames

3.10 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install refrigertant piping s specified in section 232300

E. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.11 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

A. General Requirements for Drain Piping and Tubing:
   1. Install a union in piping at each threaded unit connection.
   2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
   3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:
      a. Details indicated on Drawings.
      b. Manufacturer's requirements.
      c. Governing codes.
      d. In the absence of requirements, comply with requirements of ASHRAE handbooks.
   4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
   5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:
   1. Slope piping from unit connection toward drain termination at a constant slope of not less than one percent.

C. Pumped Drains:
   1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.12 ADDITIONAL REFRIGERANT PIPING REQUIREMENTS

A. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:
   1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Install traps to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

3.13 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

3.14 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service. Complete installation and startup checks according to manufacturer's written instructions

3.15 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

B. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of eight (8) hours of instruction at the site, during start-up.
   3. Provide six (6) hours of instruction at the site after start-up
      a. Provide two (2) hours at three (3) months after start-up training
      b. Provide two (2) hour at six (6) months after start-up training.
      c. Provide two (2) hour at nine (9) months after start-up training

END OF SECTION 238126

SECTION 238229 - RADIATORS

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 flat-pipe steel radiators.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:
   1. Include plans, elevations, sections, and 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. Indicate location and size of each field connection.
   4. Indicate location and arrangement of piping valves and specialties.

C. Color Samples for Initial Selection: For radiators with factory-applied color finishes.

PART 2 - PRODUCTS

2.1 DOUBLE FINNED PANEL, FLAT-PIPE STEEL RADIATORS

A. Manufacturer: Runtal

B. Heating Elements: Steel, welded and formed into flat, square, steel header with minimum thickness of 0.109 inch. Include threaded piping and air-vent connections.
   1. Working Pressure: 56 psig; 0.048 inch.

C. Mounting: Wall Mounted.

D. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.

E. Accessories:
   1. Steel piping covers finished to match radiator finish.

2. Flexible Expansion Compensation Hoses: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 deg F.
   a. Length: 24 inches.
   b. Minimum Diameter: Equal to connection size.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive radiators for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic-piping connections to verify actual locations before installation of radiators.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install units level and plumb.

B. Install expansion compensation hoses.

C. Install piping covers.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect radiators and components to piping according to Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties."
   1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

C. Install control valves as required by Section 230923.11 "Control Valves."

D. Install piping adjacent to radiators to allow service and maintenance.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238229

SECTION 238239.13 - CABINET 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: Cabinet unit heaters with centrifugal fans and hot-water heating coils.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. DDC: Direct digital control.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:
   1. Include plans, elevations, sections, and 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 location and size of each field connection.
   4. Include details of anchorages and attachments to structure and to supported equipment.
   5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
   6. Indicate location and arrangement of piping valves and specialties.
   7. Indicate location and arrangement of integral controls.
   8. Wiring Diagrams: Power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cabinet unit heaters operation, and maintenance manuals.

1.6 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. Cabinet Unit-Heater Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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. Rittling.
   2. Modine.
   3. Sigma
   4. Sterling.
   5. Trane.

2.2 DESCRIPTION

A. Factory-assembled and -tested unit complying with AHRI 440.

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 UL 2021.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 COIL SECTION INSULATION

A. Insulation Materials:
   1. Duct-Liner-Type, Glass-Fiber Insulation: ASTM C1071; surfaces exposed to airstream are to have aluminum-foil facing to prevent erosion of glass fibers.
      a. Thickness: 1 inch.
      b. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
      c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested in accordance with ASTM E84.
      d. Adhesive: Comply with ASTM C916 and with NFPA 90A or NFPA 90B.
      e. Airstream Surfaces: Surfaces in contact with the airstream comply with requirements in ASHRAE 62.1.

f. Airstream Surfaces: Surfaces in contact with the airstream comply with requirements in ASHRAE 62.1.

2.5 CABINETS

A. Material: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
   1. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch- thick galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
   2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0528-inch- thick galvanized sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
   3. Recessed Flanges: Steel, finished to match cabinet.
   4. Control Access Door: Key operated.
   5. Base: Minimum 0.0528-inch-thick steel, finished to match cabinet, 4 inches high with leveling bolts.
   6. False Back: Minimum 0.0428-inch-thick steel, finished to match cabinet.

2.6 UNIT FINISH

A. All cabinet exposed recessed are cleaned, bonderized, phosphatized, and painted with a baked powder finish meets ASTM B117 specifications (salt spray test).

2.7 FANS

A. The galvanized blades are corrosion resistant. Fan housing construction is formed sheet metal.

2.8 MOTORS

A. All motors have integral thermal overload protection with a maximum ambient operating temperature of 104°F and are permanently lubricated. Motors are capable of starting at 50 percentof rated voltage and operating at 90 percent of rated voltage on all speed settings. Motors can operate up to 10 percent over voltage.

2.9 CONTROL INTERFACE

A. The control interface is intended to be used with a field-supplied, low-voltage thermostat or controller. The control box contains a relay board which includes a line voltage to 24-volt transformer, quiet contactors (for electric heat units), and an optional disconnect switch. All end devices are wired to a low-voltage terminal block and are run-tested, so the only a power connection and thermostat connection is needed to commission the unit.

2.10 FILTERS

A. Minimum Efficiency Reporting Value: In accordance with ASHRAE 52.2.

B. Material:

1. Glass fiber treated with adhesive, MERV 5.

2.11 COILS

A. 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 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

2.12 DISCONNECT SWITCH

A. A unit – mounted disconnect switch.

2.13 CONTROLS

A. 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 230500 "Common Work Results for HVAC."
   3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

B. 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."

C. Terminal Controller: DDC.
   1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
   2. Unoccupied Period Override: Two hours.
   3. Unit Supply-Air Fan Operations:
      a. Occupied Periods: Fan runs continuously.
      b. Unoccupied Periods: Fan cycles to maintain setback room temperature.
   4. Heating-Coil Operations:
      a. Occupied Periods: Open control valve to provide heating if room temperature falls below thermostat set point.
      b. Unoccupied Periods: Start fan and open control valve if room temperature falls below setback temperature.
   5. Controller is to have volatile-memory backup.

D. Interface with DDC System for HVAC Requirements:
   1. Interface relay for scheduled operation.
   2. Interface relay to provide indication of fault at central workstation.
   3. Interface is to be BAC-net compatible for central DDC system for HVAC workstation and include the following functions:
      a. Adjust set points.
      b. Cabinet unit-heater start, stop, and operating status.
      c. Data inquiry, includingsupply-air and room-air temperature.

d. Occupied and unoccupied schedules.

E. Electrical Connection: Factory-wired motors and controls for a single field connection.

2.14 PIPING KIT

A. Factory, Hot-Water Piping Package: ASTM B88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
1. Two-way, modulating control valve.
2. Hose Kits: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.
   a. Length: 24 inches.
   b. Minimum Diameter: Equal to cabinet unit-heater connection size.
3. 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.
4. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
5. Automatic Flow-Control Valve: Brass or ferrous-metal body, 300-psig working pressure at 250 deg F, with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow within plus or minus 10 percent of differential pressure range of 2 to 80 psig.
6. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A126, Class B); 125-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.
7. Wrought-Copper Unions: ASME B16.22.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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 OF CABINET UNIT HEATERS

A. Install cabinet unit heaters to comply with NFPA 90A.

B. Suspend cabinet unit heaters from structure with elastomeric hangers. Vibration isolators are specified in Section 230548.13 "Vibration Controls for HVAC."

C. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

D. Install wall-mounted 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.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping," Section 232116 "Hydronic Piping 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. Comply with safety requirements in UL 1995.

E. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of cabinet unit heater. Steam specialties are specified in Section 232216 "Steam and Condensate Heating Piping Specialties."

F. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   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.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

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. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of two (1) hours of instruction at the site, during start-up.

END OF SECTION 238239.13

SECTION 238239.14 - 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 unit heaters with propeller fans and hot-water coils.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. DDC: Direct digital control.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:
   1. Include plans, elevations, sections, and 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 location and size of each field connection.
   4. Include details of anchorages and attachments to structure and to supported equipment.
   5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
   6. Indicate location and arrangement of piping valves and specialties.
   7. Indicate location and arrangement of integral controls.
   8. Wiring Diagrams: Power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For unit heaters operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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. Rittling.
   2. Modine.
   3. Sigma
   4. Sterling.
   5. Trane.

2.2 DESCRIPTION

A. Factory-assembled and -tested unit complying with AHRI 440.

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 UL 2021.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 CABINETS

A. Material: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
   1. Suspended, Exposed unit
   2. Galvanized sheet steel.

2.5 UNIT FINISH

A. All cabinet exposed recessed are cleaned, bonderized, phosphatized, and painted with a baked powder finish meets ASTM B117 specifications (salt spray test).

2.6 FANS

A. The galvanized propeller blades are corrosion resistant. Fan housing construction is formed sheet metal.

2.7 MOTORS

A. All motors have integral thermal overload protection with a maximum ambient operating temperature of 104°F and are permanently lubricated. Motors are capable of starting at 50 percentof rated voltage and operating at 90 percent of rated voltage on all speed settings. Motors can operate up to 10 percent over voltage.

2.8 CONTROL INTERFACE

A. The control interface is intended to be used with a field-supplied, low-voltage thermostat or controller. The control box contains a relay board which includes a line voltage to 24-volt transformer, quiet contactors (for electric heat units), and an optional disconnect switch. All end devices are wired to a low-voltage terminal block and are run-tested, so the only a power connection and thermostat connection is needed to commission the unit.

2.9 COILS

A. 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 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

2.10 DISCONNECT SWITCH

A. A unit – mounted disconnect switch.

2.11 BAR GRILLE INLET/OUTLET

A. Adjustable horizontal blades on the discharge of all units and wire guards on the return.

2.12 PIPING KIT

A. Factory, Hot-Water Piping Package: ASTM B88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
   1. Two-way, two-position control valve.
   2. Hose Kits: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.
   3. Two-Piece, Ball Valves: Bronze body with full-port, stainless steel ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
   4. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
   5. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A126, Class B); 125-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.
   6. Wrought-Copper Unions: ASME B16.22.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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 cabinet unit heaters to comply with NFPA 90A.

B. Suspend cabinet unit heaters from structure with elastomeric hangers.

C. Install wall-mounted 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.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping," Section 232116 "Hydronic Piping Specialties." 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. Comply with safety requirements in UL 1995.

E. 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 cabinet unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

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 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   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.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

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 AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

B. The following training shall be accomplished after the completion of each phase
   1. Provide competent technical instruct the Owner's operating personnel and turn over three (3) copies of equipment Operational and Maintenance Manuals.
   2. Provide a total of two (1) hours of instruction at the site, during start-up.

END OF SECTION 238239.14

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Basic Electrical Requirements specifically applicable to Division 26 sections, in addition to Drawings and general provisions of the Contract, including Division 01 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

A. All Division 26 section noted included in the Project Manuals.

1.3 REGULATORY REQUIREMENTS

A. Products requiring electrical connection: listed and classified by underwriters' laboratories, as suitable for the purpose specified and indicated.

1.4 DEFINITIONS

A. 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.

B. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

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

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

E. Finished Spaces: Spaces other than mechanical, plumbing and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, space above ceilings, unexcavated spaces, crawl spaces, and tunnels.

F. Furnish: Contractor shall supply (purchase) item and turn over to others for installation.

G. Install: Others shall purchase item and the contractor shall place item in position for service and or use.

H. Provide: Contractor shall furnish (purchase) and completely install item.

I. Owner: Binghamton University

J. Salvage: Remove unused existing equipment where accessible and offer salvage material to the owner. Owner shall have first right of refusal of salvageable materials removed from the building. Materials not claimed by the owner shall become the property of the contractor. The contractor shall dispose of material not retained by the owner in a lawful and legal manner away from the site.

K. Storage: To provide a safe warehousing location to protect equipment and components that are to be implemented as part of the project. This includes but not limited to existing items to be relocated by the owner/contractor and items purchased by the owner/contractor.

1.5 PERFORMANCE

A. All work shall be performed in cooperation with the Owner, Architect and other separate contractors. The contractor shall coordinate work with the construction schedule established by the Owner and Architect and shall immediately report any delays in materials receipt including circumstances causing the delays.

1.6 SUBMITTALS

A. Refer to Division 1
   1. Submittal procedures.
   2. Shop Drawings and Samples.
   3. Coordination Drawings.

B. Product Data: For products listed under Part 2 of Division 26 technical specifications.

C. Submit to architect/engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.

D. Submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to the architect/engineer for product data.

E. Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information specific to this project. Submittals that are not properly marked with all pertinent information identified will be returned.

F. Submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to the architect/engineer for product data.

G. Product data: published literature: indicate dimensions, weights, capacities, ratings, gages and finishes of materials, electrical characteristics and connection requirements.

H. Shop drawings: indicate assembly, dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics and connection requirements.

I. Manufacturer's instructions: Include installation instructions.

J. Maintenance data: Include instructions for lubrication, replacement parts, motor and drive replacement, spare parts lists, and wiring diagrams.

K. In addition, the submittal shall bear the project name, the contractor's name, the date reviewed by the contractor, the contractor's control number (if applicable), and a stamp with the contractor's signature certifying that the item has been reviewed and it complies with the requirements of the contract documents.

L. Any submittals not clearly marked as indicated above will be returned to the contractor for resubmission.

1.7 CLOSEOUT SUBMITTALS

A. Provide 3-ring binder with the following items to be used as facility Operation and Maintenance Manual.
   1. Product Date: Provide one copy of final approved product data for products listed under Part 2 of Division 26 technical specifications.
   2. Manufacturer's instructions: Including installation instructions.
   3. Manufacturer's data: Include instructions for lubrication, replace parts, motor and drive replacement, spare parts list, and wiring diagrams.

B. Upon completion of installation, prior to Owner accepting portions of building and equipment for operational use, instruct the Owner's operating personnel in the operation of the systems and equipment. Instruction shall be performed by equipment and controls vendors' factory-trained personnel. Owner shall determine which systems require additional instruction. Duration of training shall vary based on the piece of equipment that will be accepted by Owner. Duration of instructions for controls shall take the equipment through a complete cycle of operation (at least five working days). Make adjustments under operating conditions.

C. Provide electronic Operation and Maintenance Manuals at the completion of the project. Contractor shall obtain, at time of purchase of equipment, electronically formatted versions of operation, lubrication, and maintenance manuals for all items. Contractor shall assemble this literature along with other information in coordinated electronic manuals with additional information describing combined operation of field assembled units, including as-built wiring diagrams.

D. Provide a list containing names and addresses of manufacturers and local representatives who stock or furnish repair parts for items or equipment.

E. Divide manuals into three sections or books as follows:
   1. Engineering flow diagrams and controls sequences from project plumbing drawings, approved automatic temperature controls submittal, equipment startup procedures and operational instructions. Startup and operational instructions shall list valves, switches, and other devices used to start, stop, and control systems. Describe procedures to be followed in case of malfunctions. Include approved valve directory showing each valve number, location of each valve, and equipment or fixture controlled by the valve.
   2. Detailed maintenance and troubleshooting manuals containing data furnished by the manufacturer for complete maintenance. Include a copy of the balancing report.
   3. Lubrication instructions detailing the type of lubricant, amount, and intervals recommended by the manufacturer for each item of equipment. Include additional instructions necessary for the implementation of a first-class lubrication program. Where appropriate, include an approved summary of the lubrication instructions in a chart form.

F. Submit an electronic format version of the manual(s) to the Architect for approval. After approval, submit electronic version and one hard copy for the Architect's distribution to the Owner. Deliver manuals no less than 30 days prior to acceptance of the equipment to

permit the Owner's personnel to become familiar with the equipment and operation prior to acceptance.

1.8 SUBSTITUTIONS

A. Submittal of substitute equipment performance data shall be made in strict adherence to the requirements set forth in Division 01 General Requirements, Supplemental General Requirements and in Instructions to Bidders.

1.9 SEQUENCING AND SCHEDULING

A. Coordinate electrical equipment installation with other building components.

B. Arrange for openings in building structure during progress of construction to allow for electrical installations.

C. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work.

D. Coordinate requirements for access panels and doors if electrical items requiring access are concealed behind finished surfaces.

1.10 QUALITY ASSURANCE

A. Electrical Characteristics for 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.

B. Furnish and install necessary equipment and materials required to provide a complete electrical system as shown on the Drawings.

C. System shall be in place tested (as specified), inspected and approved by all authorities having jurisdiction (where applicable).

D. Materials furnished and installations made under this specification shall conform to applicable requirements of the codes, regulations and standards described herein, unless specifically described otherwise.

E. If any codes, standards or regulations conflict, the most stringent shall apply.

F. Systems shall comply with the latest version and associated references standards of the following codes:
   1. Code compliance: all work shall comply with or surpass the requirements of the New York State codes and reference standards. Conform to applicable code for the work described within the contraction documents.
   2. Systems shall comply with the latest version and associated references standards of the following codes:
      a. 2020 Building Code of New York State
      b. 2020 Energy Conservation Construction Code of New York State
      c. 2020 Existing Building Code of New York State

d. 2020 Fire Code of New York State
e. 2020 Fuel Code of New York State
f. 2020 Plumbing Code of New York State
g. 2020 Mechanical Code of New York State
h. 2020 Property Maintenance Code of New York State
i. 2020 Residential Code of New York State

3. Systems shall comply with the latest version of the following codes referenced standards:
   a. NFPA 70 – 2017 National Electrical Code
   b. NFPA 72 – 2016 National Fire Alarm and Signaling Code
   c. NFPA 110 – 2016 Emergency and Standby Power Systems
   d. Others as Identified

4. All work shall meet the requirements of the afore mentioned codes and all codes and standards referenced in the specifications. Although the details of such work may not be shown on the drawings or referenced in the specifications
5. Conflicts between the applicable codes, standards, and the plans and specifications must be brought to the attention of the engineer prior to proceeding with the work in question.
6. Conflicting standards: in case of conflict between the contract documents and a governing code or ordinance, the more stringent standard shall apply.

G. Materials and equipment installations shall comply with standards of:
   1. National Fire Protection Agency (NFPA).
   2. Local Utilities.
   3. Owner's Insurance Underwriters.
   4. Applicable Government Agencies and Departments.
   5. Underwriters Laboratory (UL).
   6. Federal and State Occupational Safety and Health Act (OSHA).
   7. Local Municipality.
   8. Local Fire Department.
   9. American Gas Association (AGA).
   10. ANSI - American National Standards Institute.
   11. ASTM Regulations and Standards for pipe, fittings, pressure vessels, testing and insulation.
   12. Conformance with the applicable codes, rules and regulations of the State of New York, NYCRR, Code Rule 4 and Code Rule 14, pertaining to boilers, gas and oil burners, controls and protective devices.
   13. AWWA American Water Works Association.
   14. Electrically powered equipment shall comply with the National Electric Code (NEC) and shall be UL listed for the intended usage.
   15. The Joint Commission (TJC).

H. Interpretations
   1. The Engineer shall provide advisory interpretations to the code regulations as requested by the contractor during construction.
   2. The Department of State is the “Authorities having Jurisdiction” Construction must comply with their requirements. Work discovered not to be in compliance to the Authorities interpretation of the code regulations shall be corrected by the contractor at no additional cost to the owner.

I. Manufacturer qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

J. Approved Manufacturers:
   1. A listed approved manufacturer does not relieve or relax any specification requirements.
   2. Manufactures listed in the specifications and or under addendum still must fully comply with the technical description as described in the project documents.
   3. Inferior manufacturers standard offerings of products will not be accepted in lieu of the specified product.
   4. The Architect/Engineer shall make the final judgment in determining if a product meets the full intent of the specifications.

1.11 CONNECTIONS

A. Furnish and install utilities serving equipment which is to be furnished by others in accordance with the sizes and locations shown on the drawings complete with final connections including provisions for shut-off and adapters as required.

B. Furnish and install required conduit and fittings as noted or specified.

C. Provide disconnects at each unit.

1.12 STRUCTURAL SUPPORTS

A. Furnish and install brackets and/or supports for the electrical installations in excess of building structure as shown on drawings. Where detail is not shown, submit shop drawings of intended construction for approval.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Deliver conduits 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.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

D. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.14 COORDINATION

A. Layout of equipment, conduits, etc. is diagrammatic. Check project drawings prior to making installations for interferences with other trades. Should the contractor find such interferences, he shall be responsible for coordinating his work with the other responsible trades. Owner reserves the right to make reasonable changes prior to "roughing-in" without added expense. Dimensions shown are subject to verification of exact site conditions.

B. Refer to reflected ceiling plans, structural drawings and architectural drawings and coordinate electrical installations with ceiling patterns, lighting layouts, building

structural members, etc. Coordinate the electrical installations with the work of others engaged in the installation to preclude the possibility of interference with electrical installations shown on the drawings.

C. Arrange for spaces, chases, slots, and openings in building structure during progress of construction, to allow for electrical installations.

D. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

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

F. Equipment configuration and layout has been developed on the 'basis of design equipment' noted in the equipment schedules. Final placement and layout of the equipment in the mechanical and electrical rooms shall be coordinated by the contractor based on the approved submittals to achieve recommended equipment clearances as required by the equipment manufacturer and maintenance clearances. The contractor shall be required to develop equipment room coordination plans noting the location of the equipment, piping, and other major components in the mechanical room prior to installation. Coordination drawings shall be submitted for approval.

G. All systems serving other areas of owner-occupied facilities shall remain fully active at all times. System shutdowns shall be coordinated with owner field representative as required to accomplish system tie in, system extension and/or system removal work.

H. All work on existing systems that are to remain active during construction shall be accomplished as coordinated with owner field representative.

I. Systems serving other areas of the owner-occupied facilities shall remain active at all times.

J. If a system serving the owner-occupied area is interrupted or made nonfunctional due to this project construction activity, the contractor disabling the service shall provide temporary services as required to keep owner operations fully functional within owner occupied facility.

K. System shutdowns shall be coordinated with owner field representative as required to accomplish system tie in, system extension and/or system removal work.

L. Duct detectors shall be furnished per Division 26, installed per Division 23, and wired per Division 26.

1.15 PROJECT CONDITIONS

A. Contract Drawings are in part diagrammatic, intended to convey to the Contractor for the Electrical Work, the scope of work and indicate general arrangement of equipment and outlets. Follow these drawings in laying out the work. Verify spaces in which the work will be installed.

B. Verify location of existing utilities before proceeding with the work.

C. Proposed conduit routing to match existing materials being connected into unless noted otherwise.

D. Verify scope of work: Contractor shall visit the job site prior to submitting a bid to ascertain existing field conditions and to determine the scope of the work, and to become familiar with the existing conditions that will affect his work and, therefore, the bid. Additional cost resulting from the contractor's failure to verify the scope of the work shall be the contractor's responsibility and shall be paid by the contractor.

E. Erect and maintain temporary partitions to prevent spread of dust, odors, and noise to permit continued owner occupancy throughout the building.

F. Work areas are to be kept free of debris at all times and are to be left broom clean at the end of each working day.

G. Adjacent areas are to be protected from dust and debris.

H. Do not close or obstruct egress width to any building or site exit.

I. Contractor shall obtain and pay for required permits from authorities.

J. Conform to applicable code for the work described within the construction documents. Base bid amount shall include additional work required by the authorities having jurisdiction pertaining to the completion of this project.

K. Contractors shall follow owner's safety requirements during construction.

L. Conform to owner's safety procedures if hazardous or contaminated materials are discovered.

M. The owner shall direct the contractor where to store salvaged items, equipment and materials removed from the work area.

N. The owner shall direct the contractor where construction materials, furniture and equipment to be installed shall be staged and stockpiled during construction.

O. The work specified herein and indicated on drawings shall be completed, tested and made ready for operation prior to turn over to the owner. Unless specifically indicated, materials and equipment shall be new and first-class quality.

P. Follow owner's safety requirements during construction.

Q. Obtain and pay for required permits from authorities.

1.16 SYSTEMS

A. The contractor shall be responsible to provide complete and operable systems, including operational properties to the extent necessary to link multiple components of a system together and to interface with other systems.

1.17 BASIS OF DESIGN EQUIPMENT

A. Drawings equipment schedules. Add the following general note.
   1. Manufacturer and Model number of equipment included in schedule is the basis of design for project.
   2. Adjustment shall be made by the contractor for equipment other than the bases of design to comply the installed equipment manufacturer's requirements.

B. Project Manual Add the following general note.
   1. Manufacturer and Model number of equipment included in specifications is the basis of design for project.
   2. Adjustment shall be made by the contractor for equipment other than the bases of design to comply the installed equipment manufacturer's requirements.

1.18 SALVAGED ITEMS

A. Remove all unused existing equipment where accessible and offer all salvage material to the owner.

B. Owner shall have first right of refusal of all salvageable materials removed from the building.

C. Materials not claimed by the owner shall become the property of the contractor.

D. The contractor shall dispose of all material not retained by the owner in a lawful and legal manner away from the site

E. Items salvaged shall be moved and stored in a location as directed by the owner.

F. The owner shall direct the contractor where to store salvaged items, equipment and materials removed from the work area.

G. At the start of the project, the Owner and contractor shall survey the building and identify all items to be salvaged and turn over to the owner

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials and equipment shall be in strict accordance with the parameters hereinafter specified and as shown on the drawings.

B. Materials and equipment furnished/provided shall be new unless noted otherwise.

2.2 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

B. Sealing Elements: NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. Pressure Plates: Carbon steel. Include two for each sealing element.

D. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 ACCESSORIES

A. It is the intent of this specification that systems and equipment shall be complete with all accessories required to insure a complete system.

2.4 ELECTRICAL CONNECTIONS

A. The contractor for HVAC/Mechanical/Plumbing equipment shall provide required motor disconnects, starters and VFDs for equipment motors unless specified and noted elsewhere.
   1. Unless noted otherwise in the construction documents, it is the HVAC/Mechanical contractors' responsibility to coordinate with the Electrical Contractor to determine what components are to be provided by each contractor.

B. The contractor for Electrical equipment shall provide required motor disconnects and starters for equipment motors unless specified and noted elsewhere.

C. It is the Electrical contractor's responsibility to coordinate with the other contractors to determine what components are to be provided by each contractor.

D. Equipment that may require starters and disconnects shall include but not be limited to fans, pumps, air handlers, compressors, terminal units, etc.

E. Electrical components provided shall be in compliances and sized in accordance with the National Electrical Code NFPA 70.

F. Electrical equipment shall be UL listed.

G. Division 26 shall provide all wiring to equipment connections.

2.5 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

2.6 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
   2. Basis of Design: Subject to compliance with requirements, provide products by the manufacturers specified.

PART 3 - EXECUTION

3.1 DEMOLITION

A. Refer to specification Sections for "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove systems, equipment, and components indicated to be removed.
   1. Conduit to Be Removed: Remove exposed portion of conduit indicated to be removed and cap or plug remaining conduit with same or compatible piping material.
   2. Conduit to Be Abandoned in Place: Drain piping and cap or plug conduit with same or compatible piping material.
   3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. Remove all abandoned housekeeping pads for equipment that is no longer in service and has been removed. All floor mounted equipment shown to be removed is on a housekeeping pad that will need to be removed. Repair floors to match existing. (Not all pads shown on the documents)

D. The layout of conduit, equipment etc. is diagrammatic in nature. Not all components are shown on the drawings.

E. Contractor shall notify the owner in advance of any shutdown necessary of the existing systems. Minimum notification time shall be 72 hours.

F. Do not disable or disrupt building systems without 3 days prior written notice to owner.

G. Provide temporary services to maintain existing systems in service during construction.

H. Abandoned and inactive components shall be removed back to their active main or area and terminated. Including but not limited to the following conduit, raceways, or other system components shall be removed.

I. If the owner does not wish to retain the equipment, the contractor will be responsible for disposal as part of this specification. Verify status with the Director’s Representative.

3.2 CUTTING AND PATCHING

A. The contractor shall be responsible for cutting and patching as described herein or as indicated on the drawings. The contractor shall be responsible for coordinating his cutting and patching requirements with the other trades.

B. Connection of new services to existing shall be in a neat and approved manner with disturbed services restored to original condition.

C. Do cutting and patching work as noted and as necessary for the installation of the fire protection work.

D. Cut, channel, chase, and drill ceilings, and other surfaces necessary for fire protection installations. Perform cutting by skilled mechanics of trade involved.

E. Repair cut surfaces to match adjacent surfaces.

F. The contractor is responsible for cutting and patching of existing work to facilitate and to conceal the work described within these documents. Surfaces to be patched shall be finished to match the existing surface. Owner has final say as to the acceptability of the finished patched work.

G. Core drill openings in concrete floors necessary for Electrical Systems

3.3 INSTALLATION

A. Unless otherwise noted or specified, materials and equipment shall be installed in strict accordance with the manufacturer's instructions and recommendations.

B. Do not scale Drawings.

C. The location of new conduit and raceways are approximate. The exact location of piping and ductwork shall be determined in the field to:
1. Provide manufacturer's recommended clearances.
2. Avoid interference with existing conditions.
3. Avoid interference with new work of other trades.

D. Provide additional fittings as required to effect required changes in slope, direction and elevation.

E. Provide additional offsets and fittings as required to accommodate obstructions that are to remain.

F. Do not cut any structural building member without permission of the Architect.

G. Provide duct detectors for air handlers with return air volumes equal to or greater than 2,000 CFM. Duct detector shall be installed in the return ductwork prior to the air handler. **The duct detectors shall be wired back to the air handler starter and the building fire alarm main panel.** Coordinate with the Fire Alarm System
1. Upon activation of the fire alarm panel,
a. The air handler shall be shut down by the building fire alarm panel.
b. The Fire Alarm panel shall be notified the Building Management System BMS.
c. The BMS may shutdown other air handlers based on BMS programming.

H. Provide interlocking controls for air handlers with the building fire alarm system. Upon activation of the building Fire Alarm system, the fans within the air handlers shall be shut down. Coordinate installation with the manufacture of the building fire alarm system and Building Management System BMS.
1. The BMS is not a life safety system. All life safety shutdowns shall be initiated by the fire alarm panel.

2. Duct Detectors that control smoke dampers or Fire/Smoke dampers shall close the designated damper and single the fire alarm system. The FAP shall shutdown the related AHU and single the BMS

I. The actual relative locations of piping, conduit, receptacles, equipment, etc. shall be adjusted during construction according to final placement of equipment.

J. Provide required offset, transitions, fittings, and components etc. as required to complete the installation of the systems in order to conform to the building structure and existing building systems. This shall include but not be limited to piping systems, duct systems, etc.

K. Systems serving other areas of owner facilities shall remain active and fully functional throughout the duration of the project for Owner occupied areas. System shutdowns shall be coordinated with owner field representative as required to accomplish system tie in, system extension and/or system removal work.

L. Work on existing systems that are to remain active during construction shall be coordinated with owner field representative.

M. Contractor is responsible for verification of all dimensions.

N. The layout of piping, ductwork, conduit, boxes, receptacles, equipment etc. is diagrammatic in nature. After field verification of actual site conditions, provide required offsets to accommodate obstructions and final system placement without added expense.

O. Coordinate location of thermostat with light switches.

P. Unless noted otherwise, system components shall not be exposed. Conduits and raceways shall be concealed within the ceilings and wall structures.

Q. The drawings do not show all offsets or fittings required for installation. Schematic diagrams convey the configuration and system components, but not all of the fittings required for the final installation are shown.

3.4 PROTECTION

A. All materials, equipment and accessories shall be suitably protected and covered during construction.

B. Damage responsibility: The contractor shall be responsible for any loss or damage caused by him or his workmen to the facility, building surfaces or equipment during the course of construction, and shall be fully responsible for repairing or replacing as required to insure restoration to original condition.

C. Damaged items: Where items scheduled for reuse are found to be in damaged condition, the contractor shall call the attention of the owner to such items and receive further instructions prior to removal. Items damaged during removal shall be repaired or replaced by the contractor at no additional cost to the owner.

D. Repair damages: Promptly repair damage to adjacent facilities by demolition operations at no cost to the owner.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel, and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.

D. Install equipment to allow right of way for piping installed at required slope.

3.6 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.7 PAINTING AND FINISHING

A. Painting of systems, equipment, and components is specified in Division 09 Sections "Paints and Coatings."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section “Metal Fabrications” for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.9 GROUTING

A. Mix and install grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.10 CEILING SYSTEM NOTES

A. Plaster frames shall be provided for air equipment installed in plaster or gypsum board ceiling.

B. Lay-in frames shall be compatible with the ceiling grid system. Note where standard and micro-grid ceiling systems are to be installed throughout the project area. Coordinate equipment frames accordingly.

3.11 FIRE PROTECTION

A. Fire rated assemblies: Provide fire retardant NRTL approved sealant on raceway penetrations of fire rated ceilings, partitions, walls, and structural slabs. It shall be the responsibility of the Contractor to verify locations of such fire rated partitions, walls and structural slabs prior to submitting bid.

B. Fire rated assemblies: Fire rated assemblies to be penetrated shall be installed with applicable firestopping system determined by U.L. classification.

C. Fire alarm system modification shall be coordinated with the Owner's Representative before making any alterations.

3.12 ACCESS DOORS – FINISHED SURFACES

A. Coordinate with other trades to provide wall, ceiling or floor access doors at locations where equipment, data and cable raceways, j-boxes, and other components needing access that are located within concealed spaces. Typical for walls, floor and ceilings.

B. Coordinate with other trades to provide wall, ceiling or floor access doors where equipment and raceways are not exposed. Doors shall be flushed mounted with key lock, with full piano hinge sized to adequately access components and raceways.

C. Provide wall, ceiling, or floor access doors at locations where equipment, valves, j-boxes, controls, fire dampers, control dampers, and other components needing access that are located within concealed spaces that require access per code or maintenance. Typical for walls, floor, and ceilings.

D. Provide wall, ceiling, or floor access doors where valves and fittings are not exposed.

E. Access doors shall be flushed mounted with key lock to Owners keying system, with full piano hinge sized to adequately access components and not smaller than 18"x18" Wall 24"x24" Ceiling.

F. Access doors for high-risk areas shall be as per Division 8 high security access doors.

G. All access doors shall have tamper proof fasteners.

H. Doors shall be polished stainless steel finished unless noted otherwise

I. Access doors shall be rated for the assembly they are to be installed in.

J. Refer to Division 8 specifications for additional information.

K. Wall mounted components that require adjustment or manual operation shall be mounted so the top of the unit is 40” above the finish floor or below.

L. Wall mounted sensors that do not require adjustment or manual operations shall be mounted so the top of the unit is 54” above the finish floor or below.

M. Wall mounted receptacles shall be mounted a minimum of 18” above finish floor to the center of the box.

3.13 ADA WALL MOUNTING HEIGHT

A. Wall mounted components that require adjustment or manual operation shall be mounted so the top of the unit is 40” above the finish floor or below.

B. Wall mounted sensors that do not require adjustment or manual operations shall be mounted so the top of the unit is 54” above the finish floor or below.

3.14 INSPECTIONS

A. The Contractor shall have:
   1. New York Board of Fire Underwriters inspect completed installation and present Owner with certificate of inspection showing approval.
   2. Required local or municipal inspection processed and present Owner with certificate indicating approval of such governing bodies.

3.15 OWNER TRAINING

A. Conduct training sessions to familiarize facility staff with the features, operation, and maintenance of the new system.

END OF SECTION 260500

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Copper building wire.
   2. Metal-clad cable, Type MC.
   3. Fire-alarm wire and cable.
   4. Connectors and splices.

B. Related Requirements:
   1. Section 271500 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 COPPER 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. General Cable; Prysmian Group North America.
   3. Southwire Company, LLC.

C. Standards:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. 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 and with ASTM B8 for stranded conductors.

E. Conductor Insulation:
   1. Type THHN and Type THWN. Comply with UL 83.
   2. Type XHHW. Comply with UL 44.

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. Belden Inc.
   2. General Cable; Prysmian Group North America.
   3. Southwire Company, LLC.

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. 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.
   2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

E. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

F. Ground Conductor: Insulated.

G. Conductor Insulation:
   1. Type THHN/THWN. Comply with UL 83.
   2. Type XHHW. Comply with UL 44.

H. Armor: Steel * interlocked.

2.3 FIRE-ALARM WIRE AND CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Allied Wire & Cable Inc.
   2. CommScope, Inc.
   3. Superior Essex Inc.; subsidiary of LS Corp.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.
   1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.
   1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
   2. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.4 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 Business.
   3. Hubbell Utility Solutions; Hubbell Incorporated.

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: One or Two hole with standard 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:
      a. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN, single conductors in raceway.

E. Feeders in Cable Tray: Type THHN/THWN, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN, single conductors in raceway.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

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."

3.4 INSTALLATION OF FIRE-ALARM WIRE AND CABLE

A. Comply with NFPA 72.

B. Wiring Method: Install wiring in metal pathway according to Section 28311 "Digital, Addressable Fire-Alarm Systems."
   1. Install plenum cable in environmental airspaces, including plenum ceilings.
   2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system must be installed in a dedicated pathway system.
      a. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.
   3. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is not permitted.

4. Signaling Line Circuits: Power-limited fire-alarm cables must not be installed in the same cable or pathway as signaling line circuits.

C. 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 fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

E. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. 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.

3.5 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 inch of slack.

D. Comply with requirements in Section 28311 "Digital, Addressable Fire-Alarm Systems" for connecting, terminating, and identifying wires and cables.

3.6 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.

3.8 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 078410 "Through-Penetration Firestop Systems."

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Grounding and bonding conductors.
2. Grounding and bonding clamps.
3. Grounding and bonding bushings.
4. Grounding and bonding hubs.
5. Grounding and bonding connectors.
6. Intersystem bonding bridge grounding connector.
7. Grounding and bonding busbars.
8. Grounding (earthing) electrodes.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

A. Equipment Grounding Conductor:
1. General Characteristics: 600 V, THHN, copper wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. ASTM - Bare Copper Grounding and Bonding Conductor:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ERICO; brand of nVent Electrical plc.
b. Harger Lightning & Grounding; business of Harger, Inc.
2. Referenced Standards: Complying with one or more of the following:
a. Soft or Annealed Copper Wire: ASTM B3
b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.

2.2 GROUNDING AND BONDING CLAMPS

A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications; see Section 270526 "Grounding and Bonding for Communications Systems," for selection and installation guidelines.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:
1. Regulatory Requirements:
a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

D. UL KDER and KDSH - Hex-Fitting-Type Pipe and Rod Grounding and Bonding Clamp:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. ERICO; brand of nVent Electrical plc.
d. Panduit Corp.
2. General Characteristics:
a. Two pieces with zinc-plated or stainless steel bolts.
b. Clamp Material: Die-cast zinc alloy
c. Listed for outdoor use.
d. Listed for outdoor use.

E. UL KDER - Beam Grounding and Bonding Clamp :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Anderson; brand of Hubbell Utility Solutions; Hubbell Incorporated.
c. Panduit Corp.
d. Penn-Union Corp.; subsidiary of Nesco, Inc.
2. General Characteristics: Mechanical-type, terminal, ground wire access from four directions; with dual, tin-plated or silicon bronze bolts.

F. UL KDER - Exothermically Welded Connection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. ERICO; brand of nVent Electrical plc.
2. General Characteristics: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING AND BONDING BUSHINGS

A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures, and have one or more bonding screws intended to provide electrical continuity between bushing and enclosure.

Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:
1. Regulatory Requirements:
a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

D. UL KDER - Bonding Bushing :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
2. General Characteristics: Threaded bushing with insulated throat.

E. UL KDER - Grounding Bushing:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
2. General Characteristics: Threaded bushing with insulated throat and mechanical-type wire terminal.

2.4 GROUNDING AND BONDING HUBS

A. Description: Hubs with certified grounding or bonding locknut.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:
1. Regulatory Requirements:
a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

2.5 GROUNDING AND BONDING CONNECTORS

A. Source Limitations: Obtain products from single manufacturer.

B. Performance Criteria:
   1. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria:
      a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
      b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

C. UL KDER - Pressure-Type Grounding and Bonding Busbar Cable Connector:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABB, Electrification Business.
      b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   2. General Characteristics: Copper or copper alloy, for compression bonding of one or more conductor directly to copper busbar. Listed for direct burial.

D. UL KDER - Crimped Lug Pressure-Type Grounding and Bonding Busbar Terminal:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABB, Electrification Business.
      b. Harger Lightning & Grounding; business of Harger, Inc.
      c. ILSCO.
   2. General Characteristics: Cast silicon bronze, solderless compression-type wire terminals; with long barrel and two holes spaced on 5/8 or 1 inch centers for two-bolt connection to busbar.

2.6 GROUNDING AND BONDING BUSBARS

A. Description: Miscellaneous grounding and bonding device that serves as common connection for multiple grounding and bonding conductors.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:
   1. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria:
      a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

2.7 GROUNDING (EARTHING) ELECTRODES

A. Description: Grounding electrodes include rod electrodes, ring electrodes, metal underground water pipes, metal building frames, concrete-encased electrodes, and pipe and plate electrodes.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:
   1. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria:
      a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

D. UL KDER - Rod Electrode:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABB, Electrification Business.
      b. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.
      c. ERICO; brand of nVent Electrical plc.
      d. Galvan Industries, Inc.; Electrical Products Division, LLC.
   2. General Characteristics: Copper-clad steel; 5/8 inch by 8 ft.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.

B. Inspect test results of grounding system measured at point of electrical service equipment connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF BUSBARS

A. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus horizontally, on insulated spacers 2 inch minimum from wall, 6 inch above finished floor unless otherwise indicated.

3.3 SELECTION OF GROUNDING AND BONDING CONDUCTORS

A. Conductors: Install solid conductor for 10 AWG and smaller, and stranded conductors for 8AWG and larger unless otherwise indicated.

B. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.

C. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch in diameter.

D. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.

E. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.

F. Underground Grounding Conductors: Install bare copper conductor, 2/0 AWG minimum.
   1. Bury at least 30 inch below grade.
   2. Duct-Bank Grounding Conductor: Bury 12 inch above duct bank when indicated as part of duct-bank installation.

3.4 SELECTION OF CONNECTORS

A. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Connections to Structural Steel: Welded connectors.

3.5 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Special Techniques:
   1. Conductors:
      a. 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.
   2. 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.
      a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
      b. Make connections with clean, bare metal at points of contact.
      c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
      d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
      e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
      f. 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 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 disconnect-type connection is required, use bolted clamp.

g. 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 bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where 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 bolted connector.
3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

h. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

i. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft apart.

3. Electrodes:
a. Ground Rods: Drive rods until tops are 2 inch 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 below-grade connections.

4. Equipment Grounding:
a. Install insulated equipment grounding conductors with 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 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 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. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.6 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by authorities having jurisdiction

B. 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 calibrated torque wrench in accordance with manufacturer's published instructions.

C. Nonconforming Work:
1. Grounding system will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective components and retest.

D. Collect, assemble, and submit test and inspection reports.
1. Report measured ground resistances that exceed the following values:
a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 Ω.

3.7 PROTECTION

A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Support, anchorage, and attachment components.
   2. Fabricated metal equipment support assemblies.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. 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 diameter holes at a maximum of 8 inch on center in at least one surface.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. B-Line; a division of Eaton, Electrical Sector.
      b. G-Strut.
      c. Unistrut; a brand of Atkore International.
   2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
   3. Material for Channel, Fittings, and Accessories: Galvanized steel or Stainless steel, Type 304.
   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. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
   8. 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. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

D. 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.
   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) B-Line; a division of Eaton, Electrical Sector.
         2) Empire Industries, Inc.
         3) Hilti, Inc.
         4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
   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.
   6. Toggle Bolts: Stainless steel springhead type.
   7. Hanger Rods: Threaded steel.

PART 3 - EXECUTION

3.1 SELECTION

A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:
   1. NECA NEIS 101
   2. NECA NEIS 102.
   3. NECA NEIS 105.
   4. NECA NEIS 111.

B. Comply with requirements in Section 078410 "Through-Penetration Firestop Systems" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as required by NFPA 70. Minimum rod size must be 1/4 inch in diameter.

D. 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 single-bolt conduit clamps using spring friction action for retention in support channel.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 INSTALLATION OF SUPPORTS

A. Comply with NECA NEIS 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA NEIS 1, EMT may be supported by openings through structure members, in accordance with NFPA 70.

C. 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 must be weight of supported components plus 200 lb.

D. 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 New Concrete: Bolt to concrete inserts.
   2. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   3. To Existing Concrete: Expansion anchor fasteners.
   4. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inch thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inch thick.
   5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts or Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
   6. To Light Steel: Sheet metal screws.
   7. 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.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 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 078410 "Through-Penetration Firestop Systems" for firestopping at conduit and box entrances.
2. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.

1.2 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.3 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:
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. Allied Tube & Conduit; a part of Atkore International.
b. Southwire Company.
c. Thomas & Betts Corporation; A Member of the ABB Group.
d. Western Tube and Conduit Corporation.

e. Wheatland Tube Company.

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. EMT: Comply with ANSI C80.3 and UL 797.
5. FMC: Comply with UL 1; zinc-coated steel.
6. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Allied Tube & Conduit; a part of Atkore International.
   b. Southwire Company.
   c. Thomas & Betts Corporation; A Member of the ABB Group.
   d. Western Tube and Conduit Corporation.
   e. Wheatland Tube Company.
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.

C. Joint Compound for IMC, GRC, or ARC: 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. AFC Cable Systems; a part of Atkore International.
   b. Electri-Flex Company.
   c. National Pipe and Plastics
   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-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
4. LFNC: Comply with UL 1660.

B. Nonmetallic Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AFC Cable Systems; a part of Atkore International.
      b. National Pipe and Plastics
      c. Electri-Flex Company.
      d. RACO; Hubbell.
      e. Thomas & Betts Corporation; A Member of the ABB Group.
   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.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line, an Eaton business.
   2. Hoffman; a brand of nVent.
   3. MonoSystems, Inc.
   4. 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: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles 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. Crouse-Hinds, an Eaton business.
   2. Hubbell Incorporated.
   3. RACO; Hubbell.
   4. Thomas & Betts Corporation; A Member of the ABB Group.
   5. Wiremold / Legrand.

2.5 BOXES, ENCLOSURES, AND CABINETS

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. Crouse-Hinds, an Eaton business.
   2. Hubbell Incorporated.
   3. RACO; Hubbell.
   4. Thomas & Betts Corporation; A Member of the ABB Group.
   5. Wiremold / Legrand.

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. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:
   1. Material: Cast metal or sheet metal.
   2. Type: Fully adjustable.
   3. Shape: Round.
   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.

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.

K. Gangable boxes are allowed.

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. Nonmetallic Enclosures: Plastic.
   3. 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.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

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 Conduit: RNC, Type EPC-80-PVC, concrete encased.
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. Concealed in Ceilings and Interior Walls and Partitions: EMT
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
5. Damp or Wet Locations: GRC.
6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid 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.

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 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 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 of enclosures to which attached.

L. Raceways Embedded in Slabs:
   1. Run conduit larger than 1-inch 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-footintervals.
   2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   3. Arrange raceways to keep a minimum of 2 inches 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 RNC, Type EPC-40-PVC, before rising above floor.

M. Stub-ups to Above Recessed Ceilings:
   1. Use EMT, 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. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

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 trade size and insulated throat metal bushings on 1-1/2-inch 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 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 tensile strength. Leave at least 12 inches 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-inchradius control at bend points.
   2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches 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 and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
   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 temperature change.
      b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
      c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
      d. Attics: 135 deg F 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 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 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 of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
   1. Use LFMC in damp or wet locations subject to severe physical damage.
   2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

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 bottom 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.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:
   1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 310000 "Earthwork" for pipe less than 6 inches in nominal diameter.
   2. Install backfill as specified in Section 310000 "Earthwork."
   3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
   4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
   5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
      a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
      b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
   6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
   7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.

3.5 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078410 "Through-Penetration Firestop Systems."

3.6 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 260533

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Labels.
   2. Tapes and stencils.
   3. Signs.
   4. Cable ties.

1.2 ACTION SUBMITTALS

A. Product data.

PART 2 - PRODUCTS

2.1 LABELS

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN PGDQ2 for components; including UL 969.

B. UL PGDQ2 - Vinyl Wraparound Labels: Preprinted, flexible labels laminated with clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Champion America.
      c. LEM Products Inc.

C. UL PGDQ2 - Self-Adhesive Wraparound Labels: Preprinted, 3 mil thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Brother International Corporation.
      c. LEM Products Inc.
   2. Self-Lamination: Clear; UV-, weather-, and chemical-resistant; self-laminating, with protective shield over legend. Size labels such that clear shield overlaps entire printed legend.
   3. Marker for Labels:

a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
b. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. UL PGDQ2 - Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3 mil thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. Ideal Industries, Inc.
c. LEM Products Inc.
2. Minimum Nominal Size:
a. 1-1/2 by 6 inch for raceway and conductors.
b. 3-1/2 by 5 inch for equipment.
c. As required by authorities having jurisdiction.

2.2 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. Carlton Industries, LP.
c. Ideal Industries, Inc.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mil thick by 1 to 2 inch wide; compounded for outdoor use.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. Carlton Industries, LP.
c. 3M

C. Tape and Stencil: 4 inch wide black stripes on 10 inch centers placed diagonally over orange background and are 12 inch wide. Stop stripes at legends.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. HellermannTyton.
b. LEM Products Inc.
c. Marking Services Inc.
d. Pipemarker.com; Brimar Industries, Inc.

D. Floor Marking Tape: 2 inch wide, 5 mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or equivalent:
a. Brady Corporation.
b. Carlton Industries, LP.

E. Underground-Line Warning Tape:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Ideal Industries, Inc.
   c. LEM Products Inc.
2. Tape:
   a. Recommended by manufacturer for method of installation and suitable to identify and locate underground electrical and communications utility lines.
   b. Printing on tape must be permanent and may not be damaged by burial operations.
   c. Tape material and ink must be chemically inert and not be subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
3. Detectable Line-Warning Tape:
   a. Detectable three-layer laminate, consisting of printed pigmented polyolefin film, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
   b. Width: 3 inch.
   c. Overall Thickness: 5 mil.
   d. Foil Core Thickness: 0.35 mil.
   e. Weight: 28 lb/1000 sq. ft.
   f. Tensile in accordance with ASTM D882: 70 lbf and 4600 psi.

2.3 SIGNS

A. Laminated Acrylic or Melamine Plastic Signs:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Carlton Industries, LP.
   c. Marking Services Inc.
   d. emedco.
2. Engraved legend.
3. Thickness:
   a. For signs up to 20 sq. inch, minimum 1/16 inch thick.
   b. For signs larger than 20 sq. inch, 1/8 inch thick.
   c. Engraved legend with black letters on white face.
   d. Self-adhesive.
   e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.4 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. HellermannTyton.
2. Ideal Industries, Inc.
3. Marking Services Inc.

B. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN ZODZ; including UL 1565 or UL 62275.

C. UL ZODZ - Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength at 73 deg F in accordance with ASTM D638: 7000 psi.
   3. UL 94 Flame Rating: 94V-0.
   4. Temperature Range: Minus 50 to plus 284 deg F.
   5. Color: Black.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 SELECTION OF COLORS AND IDENTIFICATION MARKINGS

A. Comply with 29 CFR 1910.144 for color identification of hazards, and the following:
   1. fire-alarm equipment, including raceways, must be finished, painted, or suitably marked safety red.
   2. Ceiling-mounted hangers, supports, cable trays, and raceways must be finished, painted, or suitably marked safety yellow where less than 7.7 ft above finished floor.

B. Pipe and Conduit Labeling: Comply with ASME A13.1.

C. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.
   1. Color must be factory applied or field applied for sizes larger than 6 AWG when permitted by authorities having jurisdiction].
   2. Colors for 208Y/120 V Circuits:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
   3. Colors for 480Y/277 V Circuits:
      a. Phase A: Brown.
      b. Phase B: Orange.
      c. Phase C: Yellow.
   4. Color for Neutral (Grounded Conductor): White.
   5. Color for Equipment Ground: Green.
   6. Color for Isolated Ground: Green with two or more yellow stripes.

D. Color-Coding Instructional Signs: Self-adhesive labels, including color code for grounded and ungrounded conductors.

E. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends must be as follows:
   1. "EMERGENCY POWER."
   2. "POWER."
   3. "UPS."
   4. "COMMUNICATIONS."

F. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

G. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with conductor or cable designation, origin, and destination.

I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with conductor designation.

J. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate to be labeled with its individual, sequential designation, numbered clockwise when entering room from primary egress, composed of the following, in the order listed:
   1. Wiring closet designation.
   2. Colon.
   3. Faceplate number.

K. Equipment Room Labeling:
   1. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:
      a. Room number being served.
      b. Colon.
      c. Faceplate number.

L. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in direction of access to live parts. Workspace must comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

M. Equipment Identification Labels:
   1. Black letters on white field.
   2. Indoor Equipment: Self-adhesive label.
   3. Outdoor Equipment: Laminated acrylic or melamine sign.
   4. Equipment to Be Labeled:
      a. Panelboards: Typewritten directory of circuits in location provided by panelboard manufacturer. Panelboard identification must be in form of self-adhesive, engraved, laminated acrylic or melamine label.
      b. Enclosures and electrical cabinets.

c. Communications cabinets.
d. Access doors and panels for concealed electrical items.
e. Switchboards.
f. Transformers: Label that includes tag designation indicated on Drawings for transformer, feeder, and panelboards or equipment supplied by secondary.
g. Substations.
h. Emergency system boxes and enclosures.
i. Motor-control centers.
j. Enclosed switches.
k. Enclosed circuit breakers.
l. Enclosed controllers.
m. Push-button stations.
n. Power-transfer equipment.
o. Contactors.
p. Remote-controlled switches, dimmer modules, and control devices.
q. Uninterruptible power supplies.
r. Battery-inverter units.
s. Battery racks.
t. Power-generating units.
u. Monitoring and control equipment.
v. Computer room air conditioners.
w. Fire-alarm and suppression equipment.

3.3 INSTALLATION

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless steel machine screws with nuts and flat and lock washers.

C. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

E. Verify identity of item before installing identification products.

F. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

G. Apply identification devices to surfaces that require finish after completing finish work.

H. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

I. System Identification for Raceways and Cables under 1000 V: Identification must completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.

J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.

L. Vinyl Wraparound Labels:
   1. Secure tight to surface of raceway or cable at location with high visibility and accessibility.
   2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to location and substrate.

M. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.

N. Self-Adhesive Labels:
   1. Install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
   2. Unless otherwise indicated, provide single line of text with 1/2 inch high letters on 1-1/2 inch high label; where two lines of text are required, use labels 2 inch high.

O. Marker Tapes: Secure tight to surface at location with high visibility and accessibility.

P. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.
   1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of 6 inch where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

Q. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

R. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's instructions.

S. Underground Line Warning Tape:
   1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inch below finished grade. Use multiple tapes where width of multiple lines installed in common trench or concrete envelope exceeds 16 inch overall.
   2. Limit use of underground-line warning tape to direct-buried cables.
   3. Install underground-line warning tape for direct-buried cables and cables in raceways.

T. Nonmetallic Preprinted Tags:
   1. Place in location with high visibility and accessibility.
   2. Secure using UV-stabilized, plenum-rated cable ties.

U. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
2. Unless otherwise indicated, provide single line of text with 1/2 inch high letters on 1-1/2 inch high sign; where two lines of text are required, use labels 2 inch high.

V. Cable Ties: General purpose, for attaching tags, except as listed below:
1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

END OF SECTION 260553

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Electronic time switches.
   2. Lighting contactors.
   3. Indoor occupancy and vacancy sensors.
   4. Switchbox-mounted occupancy sensors.

1.2 ACTION SUBMITTALS

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

1.3 WARRANTY

A. Standard factory warranty for:
   1. Failures include, but are not limited to, the following:
      a. Faulty operation of lighting control devices.

PART 2 - PRODUCTS

2.1 ELECTRONIC TIME SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. Intermatic, Inc.
   3. Leviton Manufacturing Co., Inc.

B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.
   1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Contact Configuration: (2) SPST Contacts.
   3. Contact Rating: 20 A LED load, 120/208 V(ac).
   4. Programs:
      a. Eight on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
   5. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.

6. Astronomic Time: All channels.
7. Automatic daylight savings time changeover.
8. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

2.2 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Lutron
   2. Allen-Bradley/Rockwell Automation.
   3. Eaton.
   4. Square D; Schneider Electric USA.

B. Description: Electrically operated and mechanically held, combination-type lighting contactors, complying with NEMA ICS 2 and UL 508.
   1. Current Rating for Switching: Listing or rating consistent with type of load served, including LED lighting loads.
   2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
   3. Enclosure: Comply with NEMA 250.

2.3 INDOOR OCCUPANCY AND VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Lutron (BASIS OF DESIGN)
   2. Sensor Switch, Inc.
   3. WattStopper; Legrand North America, LLC.

B. General Requirements for Sensors:
   1. Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
   2. Dual technology.
   3. Separate power pack.
   4. Hardwired connection to switch.
   5. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   6. Operation:
      a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
      b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
      c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   7. Sensor Output: Sensor is powered from the power pack.

8. Power: Line voltage.
9. Power Pack: (2) Dry contacts, one for lighting and one for HVAC equipment, rated for 20 A LED load at 120 and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
10. Mounting:
    a. Sensor: Suitable for mounting in any position in a standard device box or outlet box.
    b. Relay: Externally mounted through a 1/2 inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
2. 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. inch, and detect a person of average size and weight moving not less than 12 inch in either a horizontal or a vertical manner at an approximate speed of 12 inch/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96 inch high ceiling.

2.4 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Lutron Electronics Co., Inc.
2. Sensor Switch, Inc.
3. WattStopper; Legrand North America, LLC.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox using hardwired connection
1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
4. Switch Rating: Not less than 800 VA LED load at 120 V, 1200 VA LED load at 277 V, and 800 W incandescent.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SENSORS

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. 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 instructions.

3.3 INSTALLATION OF CONTACTORS

A. Mount lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.4 INSTALLATION OF WIRING

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.

C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 IDENTIFICATION

A. Identify components and power and control wiring in accordance with Section 260553 "Identification for Electrical Systems.
   1. Identify controlled circuits in lighting contactors.
   2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.6 FIELD QUALITY CONTROL

A. 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.

B. Nonconforming Work:
   1. Lighting control devices will be considered defective if they do not pass tests and inspections.
   2. Remove and replace defective units and retest.

C. Prepare test and inspection reports.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
   1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
   2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.

END OF SECTION 260923

SECTION 260943.23 - RELAY-BASED LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Networked lighting control panels.
2. Manual switches and cover plates.
3. Field-mounted signal sources.
4. Conductors and cables.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, relays, manual switches and cover plates, and conductors and cables.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Sound data including results of operational tests of central dimming controls.
4. Operational documentation for software and firmware.

B. Shop Drawings: For each relay panel and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than Type 1.
3. Detail wiring partition configuration, current, and voltage ratings.
4. Short-circuit current rating of relays.
5. Address Drawing: Reflected ceiling plan and floor plans, showing connected luminaires, address for each luminaire, and luminaire groups. Base plans on construction plans, using the same legend, symbols, and schedules.
6. Point List and Data Bus Load: Summary list of all control devices, sensors, ballasts, and other loads. Include percentage of rated connected load and device addresses.
7. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.

1.3 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. Lighting Control Relays: Equal to 10 percent of amount installed for each size indicated], but no fewer than 5.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panels for installation in accordance with NECA 407.

1.5 WARRANTY

A. Special Manufacturer Extended Warranty: Manufacturer warrants that components of standalone multipreset modular dimming controls perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended warranty period.

1. Initial Extended Warranty Period: Two year(s) from date of Substantial Completion, for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Sequence of Operations: Input signal from field-mounted manual switches, or digital signal sources, must open or close one or more lighting control relays in the lighting control panels. Any combination of inputs must be programmable to any number of control relays.

B. Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge suppressors complying with UL 1449, SPD Type 2.

C. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

D. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

E. Comply with UL 916.

2.2 NETWORKED LIGHTING CONTROL PANELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Lutron Athena(BASIS OF DESIGN)
2. Sensor Switch, Inc.
3. WattStopper; Legrand North America, LLC.

B. Description: Lighting control panels using mechanically latched relays to control lighting and appliances. The panels must be capable of being interconnected with digital communications to appear to the operator as a single lighting control system.

C. Lighting Control Panels:

1. A single enclosure with incoming lighting branch circuits, control circuits, switching relays, and on-board timing and control unit.
2. A vertical barrier separating branch circuits from control wiring.

D. Main Control Unit: Installed in the main lighting control panel only; powered from the branch circuit of the standard control unit.

1. Ethernet Communications: Comply with TCP/IP protocol. The main control unit must provide for programming of all control functions of the main and all networked slave lighting control panels including timing, sequencing, and overriding.
2. Web Server: Display information listed below over a standard Web-enabled server for displaying information over a standard browser.

    a. A secure, password-protected login screen for modifying operational parameters, accessible to authorized users via Web page interface.
    b. Panel summary showing the master and slave panels connected to the controller.
    c. Controller diagnostic information.
    d. Show front panel mimic screens for setting up controller parameters, input types, zones, and operating schedules. These mimic screens must also allow direct breaker control and zone overrides.

3. Timing Unit:

    a. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
    b. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
    c. Schedule periods settable to the minute.
    d. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.

4. Time Synchronization: The timing unit must be updated not less than every 24 hour(s) with the network time server.
5. Sequencing Control with Override:

    a. Automatic sequenced on and off switching of selected relays at times set at the timing unit, allowing timed overrides from external switches.
    b. Sequencing control must operate relays one at a time, completing the operation of all connected relays in not more than 10 seconds.
    c. Override control must allow any relay connected to it to be switched on or off by a field-deployed manual switch or by an automatic switch, such as an occupancy sensor.
    d. Override control "blinking warning" must warn occupants approximately five minutes before actuating the off sequence.
    e. Activity log, storing previous relay operation, including the time and cause of the change of status.
    f. Download firmware to the latest version offered by manufacturer.

E. Standard Control Unit, Installed in All Lighting Control Panels: Contain electronic controls for programming the operation of the relays in the control panel, contain the status of relays, and contain communications link to enable the digital functions of the main control unit. Comply with UL 916.

1. Electronic control for operating and monitoring individual relays, and display relay on-time.
2. Nonvolatile memory must retain all setup configurations. After a power failure, the controller must automatically reboot and return to normal system operation.
3. Integral keypad and digital-display front panel for local setup, including the following:

    a. Blink notice, time adjustable from software.
    b. Ability to log and display relay on-time.
    c. Capability for accepting downloadable firmware so that the latest production features may be added in the future without replacing the module.

F. Relays:

1. Electrically operated, mechanically held single-pole switch, rated at 20 A at 277 V. Short-circuit current rating must be not less than 5 kA. Control must be three-wire, 24 V(ac) and digital control network.

G. Power Supply: NFPA 70, Class 2, UL listed, sized for connected equipment, plus not less than 20 percent spare capacity. Powered from a dedicated branch circuit of the panelboard that supplies power to the line side of the relays, sized to provide control power for the local panel-mounted relays, bus system, control-voltage inputs, field-installed occupancy sensors, and control-voltage photo sensors.

H. Operator Interface: At the main control unit, provide interface for a tethered connection of a portable PC running MS Windows for configuring all networked lighting control panels using setup software designed for the specified operating system. Include one portable device for initial programming of the system and training of Owner's personnel. That device must remain the property of Owner.

I. Software:

1. Menu-driven data entry.
2. Online and offline programming and editing.
3. Provide for entry of the room or space designation for the load side of each relay.
4. Monitor and control all relays, showing actual relay state and the name of the automatic actuating control, if any.
5. Size the software appropriate to the system.

2.3 MANUAL SWITCHES AND COVER PLATES

A. Push-Button Switches: Modular, momentary contact, three wire, for operating one or more relays and to override automatic controls.

1. Match color and style specified in Section 262726 "Wiring Devices."
2. Integral green LED pilot light to indicate when circuit is on.
3. Internal white LED locator light to illuminate when circuit is off.

B. Cover Plates: Single and multigang cover plates as specified in Section 262726 "Wiring Devices."

C. Legend: Engraved or permanently silk-screened on cover plate where indicated. Use designations indicated on Drawings.

2.4 FIELD-MOUNTED SIGNAL SOURCES

A. Daylight Harvesting Switching Controls: Comply with Section 260923 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal must be compatible with the relays.

B. Indoor Occupancy Sensors and Extreme-Temperature Occupancy Sensors: Comply with Section 260923 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal must be compatible with the relays.

2.5 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

D. Twisted-Pair Data Cable: Category 5e.
   1. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panels in accordance with NECA 407.

B. Examine panels before installation. Reject panels that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panels for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF WIRING

A. Wiring Methods:

1. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters.
2. Install cables in raceways and cable trays except within consoles, cabinets, desks, counters, accessible ceiling spaces, and gypsum board partitions where unenclosed wiring method may be used.
3. Install conductors and cables concealed in accessible ceilings, walls, and floors where possible.
4. Conceal raceway and cables except in unfinished spaces.
5. Provide plenum-rated cable, where installed exposed or in open cable tray, within environmental airspaces, including plenum ceilings.
6. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
7. Comply with requirements for raceways specified in Section 260533 "Raceway and Boxes for Electrical Systems."

B. 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.

3.3 INSTALLATION OF PANELS

A. Install panels and accessories in accordance with NECA 407.

B. Mount top of trim 90 inch above finished floor unless otherwise indicated.

C. Mount panel cabinet plumb and rigid without distortion of box.

D. Install filler plates in unused spaces.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."

C. Create a directory to indicate loads served by each relay; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.

D. Lighting Control Panel Nameplates: Label each panel with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Field tests must be witnessed by Architect and Tenant.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers described below. Certify compliance with manufacturer's test parameters.

a. Circuit-Breaker Tests:

1) Compare nameplate with Drawings and Specifications.
2) Inspect physical and mechanical conditions.
3) Inspect anchorage and alignment.
4) Verify that the units are clean.
5) Operate the circuit breaker to ensure smooth operation.
6) Inspect bolted electrical connections for high resistance using one or more of the following methods:

a) A low-resistance ohmmeter.
b) Verify tightness of bolted electrical connections by calibrated torque wrench.
c) Thermographic survey.

7) Inspect operating mechanism, contacts, and arc chutes in unsealed units.
8) Perform insulation resistance tests for one minute on each pole, phase-to-phase, and phase-to-ground with the circuit breaker closed and across each pole using manufacturer's published data.
9) Perform a contact/pole-resistance test.
10) Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be for one minute. Follow manufacturer's instructions for solid-state units.
11) Test functions of the trip unit by means of secondary injection.
12) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
13) 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 trip logs and indicators.
14) Verify operation of charging mechanism.

C. Nonconforming Work:

1. Lighting control panel will be considered defective if it does not pass tests and inspections.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Prepare test and inspection reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.6 SYSTEM STARTUP

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's instructions.
2. Confirm correct communications wiring, initiate communications between panels, and program the lighting control system in accordance with approved configuration schedules, time-of-day schedules, and input override assignments.

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.

3.8 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software support for two years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Verify upgrading software includes operating system and new or revised licenses for using software.

    a. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3. Upgrade Reports: Prepare written report after each update, documenting upgrades installed.

END OF SECTION 260943.23

SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

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

B. Shop Drawings:
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.
   2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
   3. Include diagrams for power, signal, and control wiring.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Electrification Business.
   2. Eaton.
   3. Siemens Industry, Inc., Energy Management Division.
   4. Square D; Schneider Electric USA.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60 Hz service.

B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

C. Transformers Rated 15 kVA and Larger:
   1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
   2. Marked as compliant with DOE 2016 efficiency levels by qualified electrical testing laboratory recognized by authorities having jurisdiction.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70

B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.

C. Coils: Continuous windings except for taps.
1. Coil Material: Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Welded.

D. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

E. Insulation Class, 25kVA and Larger: 220 deg C, UL-component-recognized insulation system with maximum of 150 deg C rise above 40 deg C ambient temperature.

F. Grounding: Provide ground-bar kit or ground bar installed on inside of transformer enclosure.

2.4 IDENTIFICATION

A. Nameplates:
1. Self-adhesive label for distribution transformers. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for transformers.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's published instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 Ω at location of transformer.

E. Environment: Enclosures must be rated for environment in which they are located. Covers for UL 50E, Type 4X enclosures may not cause accessibility problems.

3.2 INSTALLATION

A. Construct concrete bases and anchor floor-mounted transformers in accordance with manufacturer's published instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Secure transformer to concrete base in accordance with manufacturer's published instructions.

C. Secure covers to enclosure and tighten bolts to manufacturer-recommended torques to reduce noise generation.

D. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at conduit and conductor terminations and supports to eliminate sound and vibration transmission to building structure.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Small (Up to 167 kVA Single-Phase or 500 kVA Three-Phase) Dry-Type Transformer Field Tests:
      a. Visual and Mechanical Inspection.
         1) Inspect physical and mechanical condition.
         2) Inspect anchorage, alignment, and grounding.
         3) Verify that resilient mounts are free and that shipping brackets have been removed.
         4) Verify that unit is clean.
         5) Perform specific inspections and mechanical tests recommended by manufacturer.
         6) Verify that as-left tap connections are as specified.
         7) Verify presence of surge arresters and that their ratings are as specified.
      b. Electrical Tests:
         1) Measure resistance at windings, taps, and bolted connections.
         2) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: value of index may not be less than 1.0.

3) Perform turns-ratio tests at tap positions. Test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

B. Test Labeling: On completion of satisfactory testing of units, attach dated and signed "Satisfactory Test" label to tested components.

C. Nonconforming Work:
1. Transformer will be considered defective if it does not pass tests and inspections.
2. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Assemble and submit test and inspection reports.

3.5 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262213

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Power panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Disconnecting and overcurrent protective devices.

1.2 DEFINITIONS

A. GFEP: Ground-fault equipment protection.

B. VPR: Voltage protection rating.

1.3 ACTION SUBMITTALS

A. Product Data:
1. Power panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Load centers.
4. Disconnecting and overcurrent protective devices.
5. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
6. 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 listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for series rating of installed devices.
7. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.4 CLOSEOUT SUBMITTALS

A. Warranty documentation.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing agency recognized by authorities having jurisdiction, and marked for intended location and application.

B. Comply with NEMA PB 1.

C. Comply with NFPA 70.

D. Enclosures: Flush and Surface-mounted, dead-front cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: UL 50E, Type 1.
      b. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: UL 50E, Type 5.
   2. Height: 7 ft maximum.
   3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims must cover live parts and may have no exposed hardware.
   4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims must cover live parts and may have no exposed hardware.

E. Incoming Mains:
   1. Location: Convertible between top and bottom.

F. Phase, Neutral, and Ground Buses:
   1. Material: Hard-drawn copper, 98 percent conductivity.

G. Conductor Connectors: Suitable for use with conductor material and sizes.
   1. Material: Hard-drawn copper, 98 percent conductivity.
   2. Main and Neutral Lugs: Mechanical type, with lug on neutral bar for each pole in panelboard.
   3. Ground Lugs and Bus-Configured Terminators: Mechanical type, with lug on bar for each pole in panelboard.
   4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
   5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

H. Quality-Control Label: Panelboards or load centers must be labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or

load centers must have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

I. Future Devices: Panelboards or load centers must have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

J. Panelboard Short-Circuit Current Rating:
1. Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for 100 percent interrupting capacity.

2.2 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB, Electrification Business.
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.

B. Listing Criteria: NEMA PB 1, distribution type.

C. Mains: Circuit breaker.

D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices: Fused switches.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB, Electrification Business.
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.

B. Listing Criteria: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Door-in-door construction with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Reference Standards:
1. Panelboards: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA PB 1.1.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Panelboard Nameplates: Label each panelboard with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each branch circuit device in power panelboards with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

E. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles must be located on interior of panelboard door.

F. Breaker Labels: Faceplate must list current rating, UL and IEC certification standards, and AIC rating.

G. Circuit Directory:
1. Provide directory card inside panelboard door, mounted in metal frame with transparent protective cover.
   a. Circuit directory must identify specific purpose with detail sufficient to distinguish it from other circuits.
2. Provide computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
   a. Circuit directory must identify specific purpose with detail sufficient to distinguish it from other circuits.
3. Create directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. General-use switches, dimmer switches, and fan-speed controller switches.
2. General-grade duplex straight-blade receptacles.
3. Receptacles with arc-fault and ground-fault protective devices.
4. Locking receptacles.

1.2 ACTION SUBMITTALS

A. Product Data

PART 2 - PRODUCTS

A. Toggle Switch
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
2. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
   a. Reference Standards: UL CCN WMUZ and UL 20.
4. Options:
   a. Device Color As indicated on architectural Drawings.
   b. Configuration:
      1) General-duty, 120-277 V, 20 A, single pole, double pole, three way.
5. Accessories:
   a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.2 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

A. Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
2. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
   a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
   a. Device Color: As indicated on architectural Drawings.
   b. Configuration:
      1) General-duty, NEMA 5-20R.
5. Accessories:
   a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.3 RECEPTACLES WITH ARC-FAULT AND GROUND-FAULT PROTECTIVE DEVICES

A. General-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
      b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
      c. Leviton Manufacturing Co., Inc.
   2. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   3. General Characteristics:
      a. Reference Standards: UL CCN KCXS, UL 498, and UL 943.
   4. Options:
      a. Device Color: As indicated on architectural Drawings.
      b. Configuration: Heavy-duty, NEMA 5-20R.
   5. Accessories:
      a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
      b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.4 SPECIAL-PURPOSE POWER OUTLET ASSEMBLIES

A. Ceiling-Mounted or Wall-Mounted :

1. Source Limitations: Obtain all components for each power outlet cord management assembly from single manufacturer.
2. Regulatory Requirements: Components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receptacles:
1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 INSTALLATION OF SWITCHES

A. Comply with manufacturer's instructions.

B. Reference Standards:
1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Consult Architect for resolution of conflicting requirements.

C. Identification:
1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."
    a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.

3.3 INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

A. Comply with manufacturer's instructions.

B. Reference Standards:
1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.

C. Identification:
1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.

3.4 INSTALLATION OF LOCKING RECEPTACLES

A. Comply with manufacturer's instructions.

B. Reference Standards:
1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
4. Consult Architect for resolution of conflicting requirements.

C. Identification:
1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."
a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.

3.5 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

A. Tests and Inspections:
1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

B. Nonconforming Work:
1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

3.6 FIELD QUALITY CONTROL OF LOCKING RECEPTACLES

A. Tests and Inspections:
1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.

6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

B. Nonconforming Work:
   1. Device will be considered defective if it does not pass tests and inspections.
   2. Remove and replace defective units and retest.

3.7 ADJUSTING

A. Occupancy Adjustments for Controlled Receptacles: 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.

3.8 PROTECTION

A. Devices:
   1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
   2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 262726

SECTION 262813 - 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. Enclosed switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. 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," and 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. 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 or more than 100 deg F, 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.
2. Bussman.
3. Littlefuse

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. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type RK-5: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
3. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.

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.

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 FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Motor Branch Circuits: Class RK1, time delay.
   2. Other Branch Circuits: Class RK1, time delay.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 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 262813

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Manual motor controllers.
4. Enclosures.

1.2 DEFINITIONS

A. GFEP: Ground-fault circuit-interrupter for equipment protection.

B. GFLS: Ground-fault circuit-interrupter for life safety.

C. SPDT: Single pole, double throw.

1.3 ACTION SUBMITTALS

A. Product Data:

1. 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.
2. Enclosure types and details for types other than UL 50E, Type 1.
3. Current and voltage ratings.
4. Short-circuit current ratings (interrupting and withstand, as appropriate).
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

1.4 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.5 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed enclosed switches and circuit breakers perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Source Limitations: Obtain products from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 FUSIBLE SWITCHES

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. ABB, Electrification Business.
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; Schneider Electric USA.

B. Type HD, Heavy Duty:

1. Single throw.
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. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
3. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 NONFUSIBLE SWITCHES

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. ABB, Electrification Business.
2. Eaton.

3. Siemens Industry, Inc., Energy Management Division.
4. Square D; Schneider Electric USA.

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. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.4 MANUAL MOTOR CONTROLLERS

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. ABB, Electrification Business.
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; Schneider Electric USA.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle action; marked to show whether unit is off, on, or tripped.
1. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; melting alloy type.
2. Overload Relays: NEMA ICS 2, bimetallic class as schedule on Drawings.

2.5 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, UL 50E, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: Enclosure must be gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (UL 50E Type 1) or gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (UL 50E Types 3R, 12).

C. Operating Mechanism: operating handle must be externally operable with operating mechanism being integral part of box, not cover. Cover interlock mechanism must have externally operated override. Override may not permanently disable interlock mechanism, which must return to locked position once override is released. Tool used to override cover interlock mechanism must not be required to enter enclosure in order to override interlock.

D. Enclosures designated as UL 50E Type 4, 4X stainless steel, 12, or 12K must have dual cover interlock mechanism to prevent unintentional opening of enclosure cover when circuit breaker is ON and to prevent turning circuit breaker ON when enclosure cover is open.

E. UL 50E Type 7/9 enclosures must be furnished with breather and drain kit to allow their use in outdoor and wet location applications.

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 will indicate Installer's acceptance of areas and conditions as satisfactory.

3.2 SELECTION OF ENCLOSURES

A. Indoor, Dry and Clean Locations: UL 50E, Type 1.

B. Outdoor Locations: UL 50E, [Type 3R.

C. Other Wet or Damp, Indoor Locations: UL 50E, Type 3R.

D. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: UL 50E, Type 12.

3.3 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Special Techniques:

1. 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.
2. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
3. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
4. Install fuses in fusible devices.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Testing Preparation:

B. 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 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 following methods:

1) Use 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 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 must be in accordance with manufacturer's published data. In 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 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 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 lowest value.
b. Measure contact resistance across each switchblade fuseholder. Drop values may not exceed high level of 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 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 absence of manufacturer's published data, use Table 100.1 from 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.

C. Nonconforming Work:

1. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

3.7 PROTECTION

A. After installation, protect enclosed switches and circuit breakers from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 262816

SECTION 263213 - DIESEL EMERGENCY ENGINE GENERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged diesel engine generators for emergency use with the following features:

1. Diesel engine.
2. Diesel fuel-oil system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Vibration isolation devices.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches, including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
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. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations 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 supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.3 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Certified test reports.

C. Field quality-control reports.

D. Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 3 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

1. The basis of design shall be Generac, substitutions shall be approved by owner and engineer.

A. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level 1 EPSS.

B. UL Compliance: Comply with UL 2200.

C. Engine Exhaust Emissions: Comply with EPA Tier 4 requirements and applicable state and local government requirements.

D. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator, including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

E. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 41 to 104 deg F.
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 2000 feet.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

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. EPSS Class: Engine generator shall be classified as a Class 1 according to NFPA 110.

D. Service Load: 15 KW (Base bid), 150 KW (Alternate 1)

E. Power Factor: 0.8 lagging.

F. Frequency: 60 Hz.

G. Voltage: 480 V ac.

H. Phase: Three-phase, four-wire wye.

I. Induction Method: Turbocharged.

J. Governor: Adjustable isochronous, with speed sensing.

K. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

L. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.

2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

M. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage, from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency, from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10 system requirements.

2.4 DIESEL ENGINE

A. Fuel: ASTM D975 diesel fuel oil, Grade 2-D S15.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant, from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant-system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

    a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: 12V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified.
4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least hree times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

9. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure and Mounting: NEMA 250, Type 1 wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 30.

B. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

C. Fuel Filtering: Remove water and contaminants larger than 1 micron.

D. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

E. Fuel-Oil Storage Tank: Comply with the following requirements:

1. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 24 hours's operation at 100 percent of rated power output of engine generator system without being refilled.
2. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel-supply pump at 110 percent of rated capacity, including fuel returned from engine.
3. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
4. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel-shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
5. Piping Connections: Factory-installed fuel-supply and return lines, from tank to engine; local fuel fill; vent line; overflow line; and tank drain line with shutoff valve.
6. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor control device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day

tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine generator.

2.6 CONTROL AND MONITORING

A. Automatic-Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Manual-Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

C. Provide minimum run time control set for 30 minutes, with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.

F. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.

G. Control and Monitoring Panel:

1. Digital controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter, connected to a phase selector switch.
    f. AC ammeter, connected to a phase selector switch.
    g. AC frequency meter.
    h. Generator-voltage-adjusting rheostat.

4. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication as required by NFPA 110 for Level 1 system, including the following:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.
    c. Control switch not in automatic position alarm.
    d. Overcrank alarm.
    e. Overcrank shutdown device.
    f. Low water temperature alarm.
    g. High engine temperature pre-alarm.
    h. High engine temperature.
    i. High engine temperature shutdown device.
    j. Overspeed alarm.
    k. Overspeed shutdown device.
    l. Low-fuel main tank.

        1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for the duration required for the indicated EPSS class.

    m. Coolant low-level alarm.
    n. Coolant low-level shutdown device.
    o. Coolant high-temperature prealarm.
    p. Coolant high-temperature alarm.
    q. Coolant low-temperature alarm.
    r. Coolant high-temperature shutdown device.
    s. EPS load indicator.
    t. Battery high-voltage alarm.
    u. Low-cranking voltage alarm.
    v. Battery-charger malfunction alarm.
    w. Battery low-voltage alarm.
    x. Lamp test.
    y. Contacts for local and remote common alarm.
    z. Low-starting air pressure alarm.
    aa. Low-starting hydraulic pressure alarm.
    bb. Remote manual-stop shutdown device.
    cc. Air shutdown damper alarm when used.
    dd. Air shutdown damper shutdown device when used.
    ee. Generator overcurrent-protective-device not-closed alarm.

H. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

I. Remote Alarm Annunciator: Comply with NFPA 99. An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

    1. Overcrank alarm.

2. Coolant low-temperature alarm.
3. High engine temperature prealarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low-fuel main tank alarm.
8. Low coolant level alarm.
9. Low-cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel-supply alarm.
17. Lamp test.
18. Low-cranking voltage alarm.
19. Generator overcurrent protective device not closed.

J. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

K. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator output rating.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

C. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.

3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

D. Generator Disconnect Switch: Molded-case type, 100 percent rated.

1. Trip Rating: Matched to generator output rating.
2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

E. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

F. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

1. Indicate ground fault with other engine generator alarm indications.
2. Trip generator protective device on ground fault.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide12-lead alternator.

E. Range: Provide limited range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Drip proof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.9 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Bridge-bearing neoprene, complying with AASHTO M 251 separated by steel shims.

2.10 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

PART 3 - EXECUTION

3.1 INSTALLATION

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 Owner no fewer than three working days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

B. Comply with NECA 1 and NECA 404.

C. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

D. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases.
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

E. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

F. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

G. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.2 CONNECTIONS

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

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.

C. Connect cooling-system water piping to engine generator and heat exchanger with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Connect fuel piping to engines with a gate valve and union and flexible connector.

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." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.3 IDENTIFICATION

A. Identify system components according to Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Contractor will 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. Tests and Inspections:

1. Perform tests recommended by manufacturer and in "Visual and Mechanical Inspection" and "Electrical and Mechanical Tests" subparagraphs below, as specified in the NETA ATS. Certify compliance with test parameters.

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with Drawings and the Specifications.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.
4) Verify that the unit is clean.

b. Electrical and Mechanical Tests:

1) Perform insulation-resistance tests according to IEEE 43.

a) Machines Larger Than 200 hp: Test duration shall be 10 minutes. Calculate polarization index.
b) Machines 200 hp or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.

2) Test protective relay devices.
3) Verify phase rotation, phasing, and synchronized operation as required by the application.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Perform vibration test for each main bearing cap.
6) Conduct performance test according to NFPA 110.
7) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

    a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    c. Verify acceptance of charge for each element of the battery after discharge.
    d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
8. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.

E. Coordinate tests with tests for transfer switches, and run them concurrently.

F. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

G. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

J. Remove and replace malfunctioning units and retest and reinspect as specified above.

K. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

L. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component, indicating satisfactory completion of tests.

M. The Generator shall undergo a Preacceptance Field Test PRIOR to performing the NFPA 110 Acceptance Test to help assure the Installation Acceptance Test will run smoothly. The Preac-

ceptance Test is to be performed by a factory trained technician a minimum of one week prior to the performance of the Installation Acceptance Test. The purpose of the Preacceptance Test is to:

1. Operate the Generator long enough to assure it is operating properly (verify it runs, accepts load, all the transfer switches transfer in the appropriate amount of time, etc.)
2. Determine if the system is suitable to conduct an Installation Acceptance Test.
3. Checking and adjusting equipment is done by the manufacturers field technician.
4. Verify the annunciator and manual stop button are operating.

3.5 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's authorized service representative. Include quarterly preventive maintenance and exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Parts 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 packaged engine generators.

END OF SECTION 263213.13

SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes automatic transfer switches rated 600 V and less.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
   2. Single-Line Diagram: Show connections between transfer switch, power sources, and load.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for transfer switches, accessories, and components, from manufacturer.

B. Source quality control reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 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 years from date of Substantial Completion.

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. Comply with NEMA ICS 1.

C. Comply with NFPA 99.

D. Comply with NFPA 110.

E. Comply with UL 1008 unless requirements of these Specifications are stricter.

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.
   1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
   2. Short-time withstand capability for three cycles.

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. Battery Charger: For generator starting batteries.
   1. Float type, rated 10 A.
   2. Ammeter to display charging current.
   3. Fused ac inputs and dc outputs.

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 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.

N. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ASCO Power Technologies.
2. Eaton.
3. Generac.

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: Hard-drawn copper, 98 percent conductivity.
6. Main and Neutral Lugs: Mechanical type.
7. Ground Lugs and Bus-Configured Terminators: Mechanical type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

D. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.
1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

E. 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.

F. Automatic Transfer-Switch Controller Features:
1. Controller operates through a period of loss of control power.
2. 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.

3. 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.
4. 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.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. 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."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. 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.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: 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.
13. 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.

G. Large-Motor-Load Power Transfer:
1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
2. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay

between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.

3. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

2.3 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 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. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

B. Identify components according to Section 260553 "Identification for Electrical Systems."

C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

D. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, 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 twisted pair cable according to Section 271513 "Communications Copper Horizontal Cabling."

F. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

G. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches in length.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. 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.

2. 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.
3. 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.
4. 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. 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.
   f. 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.
5. 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.

B. Coordinate tests with tests of generator and run them concurrently.

C. 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.

D. Transfer switches will be considered defective if they do not pass tests and inspections.

E. Remove and replace malfunctioning units and retest as specified above.

F. Prepare test and inspection reports.

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 263600

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following types of LED luminaires:
   1. Downlight.
   2. Highbay
   3. Suspended, Linear.
   4. Recessed, linear.
   5. Surface mount, linear.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
   2. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

1.3 INFORMATIONAL SUBMITTALS

A. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

1.6 PROCUREMENT

A. Provide 10% additional fixtures for each type listed on the lighting fixture schedule, turn over to owner for storage.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Ambient Temperature: 41 to 104 deg F.
   1. Relative Humidity: Zero to 95 percent.

B. Altitude: Sea level to 1000 feet.

2.2 LUMINAIRE 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. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
   1. Label shall include the following lamp characteristics:
      a. "USE ONLY" and include specific lamp type.
      b. Lamp diameter, shape, size, wattage, and coating.
      c. CCT and CRI.

C. Recessed luminaires shall comply with NEMA LE 4.

D. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

2.3 DOWNLIGHT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Lighting Solutions; Signify North America Corp.
   2. Juno Lighting Group by Schneider Electric.
   3. Lithonia Lighting; Acuity Brands Lighting, Inc.

B. Nominal Operating Voltage: 277 V ac.

C. Lamp:
   1. Minimum 1000lm.
   2. Minimum allowable efficacy of 80 lm/W.
   3. CRI of minimum 80. CCT of 4100 K.
   4. Rated lamp life of 50,000 hours to L70.
   5. Dimmable from 100 percent to zero percent of maximum light output.
   6. Attached driver .

D. Housings:
   1. Extruded-aluminum housing and heat sink.
   2. Clear] powder-coat finish.
   3. Universal mounting bracket.

4. Integral junction box with conduit fittings.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Fixed lens.
2. Medium Wide light distribution.
3. Clear, UV-stabilized acrylic.
4. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
5. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

G. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.
4. Recessed luminaires shall comply with NEMA LE 4.

2.4 High Bay

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Lighting Solutions; Signify North America Corp.
2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. Selux.

B. Nominal Operating Voltage: 277 V ac.

C. Lamp:
1. Minimum 10,000 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of minimum 80 . CCT of 4000 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.
7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. White powder-coat finish.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:

1. Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

G. With integral mounting provisions.

H. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.

2.5 SUSPENDED LINEAR

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Lighting Solutions; Signify North America Corp.
2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. Selux.

B. Nominal Operating Voltage: 277 V ac.

C. Lamp:
1. Minimum 4,000 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of minimum 80 . CCT of 4100 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.
7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. White powder-coat finish.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

G. With integral mounting provisions.

H. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.

2.6 RECESSED, LINEAR

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Lighting Solutions; Signify North America Corp.
   2. Finelite; Legrand North America, LLC.
   3. Lithonia Lighting; Acuity Brands Lighting, Inc.

B. Nominal Operating Voltage: 277 V ac.

C. Lamp:
   1. Minimum 4000 lm.
   2. Minimum allowable efficacy of 85 lm/W.
   3. CRI of minimum 80. CCT of 4000 K.
   4. Rated lamp life of 50,000 hours to L70.
   5. Dimmable from 100 percent to zero percent of maximum light output.
   6. Internal driver.
   7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

D. Housings:
   1. Extruded-aluminum housing and heat sink.
   2. White powder-coat finish.
   3. With integral mounting provisions.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
   1. Clear, UV-stabilized acrylic.
   2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   3. Glass: Annealed crystal glass unless otherwise indicated.
   4. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

G. Standards:
   1. ENERGY STAR certified.
   2. RoHS compliant.
   3. UL Listing: Listed for damp location.
   4. NEMA LE 4.

2.7 WALL MOUNTED VANITY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Lighting Solutions; Signify North America Corp.
   2. Finelite; Legrand North America, LLC.
   3. Lithonia Lighting; Acuity Brands Lighting, Inc.

B. Nominal Operating Voltage: 277 V ac.

C. Lamp:
1. Minimum 1300 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of 80. CCT of 4000 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.
7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. 2’-0” Fixture Length
3. White powder-coat finish.
4. With integral mounting provisions.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

G. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.8 MATERIALS

A. Metal Parts:
1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Steel:
1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for sheet steel.

C. Stainless Steel:
1. 1. Manufacturer's standard grade.
2. 2. Manufacturer's standard type, ASTM A240/240M.

D. Galvanized Steel: ASTM A653/A653M.

E. Aluminum: ASTM B209.

2.9 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.10 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:
1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 260923 "Lighting Control Devices."

B. Comply with requirements for startup specified in Section 260943.23 "Relay-Based Lighting Controls."

END OF SECTION 265119

SECTION 265213 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Exit signs.
   2. Materials.
   3. Luminaire support components.

1.2 ACTION SUBMITTALS

A. Product Data:

   1. For each type of emergency lighting unit, exit sign, and emergency lighting support.

      a. Include data on features, accessories, and finishes.
      b. Include physical description of unit and dimensions.
      c. Battery and charger for light units.
      d. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
      e. Include photometric data and adjustment factors based on laboratory tests by, or under supervision of, qualified luminaire photometric testing laboratory, for each luminaire type.

B. Product Schedule:
   1. For exit signs. Use same designations indicated on Drawings.

1.3 WARRANTY

A. Special Installer Extended Warranty for Emergency and Exit Lighting: Installer warrants that fabricated and installed emergency luminaires and exit signs, including batteries, perform in accordance with specified requirements and agrees to repair or replace components and assemblies that fail to perform as specified within extended warranty period.

   1. Extended Warranty Period: Two year(s) from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 and UL 924, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. Comply with NFPA 101.

C. Comply with NEMA LE 4 for recessed luminaires.

D. Comply with UL 1598 for fluorescent luminaires.

E. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.

F. Bulb Shape: Complying with ANSI C79.1.

2.2 EXIT SIGNS

A. General Characteristics: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Sign:

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

    a. Amerlux.
    b. Cooper Lighting Solutions; Signify North America Corp.
    c. Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    d. Lithonia Lighting; Acuity Brands Lighting, Inc.
    e. Mule Lighting, Inc.

2. Options:

    a. Operating at nominal voltage of 277 V(ac).
    b. Lamps for AC Operation:

        1) Fluorescent, two for each luminaire; 20,000 hours of rated lamp life.
        2) LEDs; 50,000 hours minimum rated lamp life.

2.3 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components must be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Prismatic acrylic Clear, UV-stabilized acrylic.
2. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing and heat sink.

2.4 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within range of approved Samples and are assembled or installed to minimize contrast.

2.5 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

B. Install lamps in each luminaire.

C. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices must be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

D. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

E. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inch, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

F. Ceiling Grid Mounted Luminaires:

1. Secure to outlet box, if provided.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect luminaires. Replace lamps, exit signs, and luminaires that are defective.

a. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

3.4 PROTECTION

A. Remove and replace luminaires and exit signs that are damaged or caused to be unfit for use by construction activities.

END OF SECTION 265213

SECTION 265619 - LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Luminaire types.
   2. Materials.
   3. Finishes.
   4. Luminaire support components.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaire.
   4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
   5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project IES LM-80.

      a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.

   6. Wiring diagrams for power, control, and signal wiring.
   7. Photoelectric relays.
   8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and photoelectric relays to include in operation and maintenance manuals.

1.5 PROCUREMENT

A. Provide 10% additional fixtures for each type listed on the lighting fixture schedule, turn over to owner for storage.

1.6 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications:

1. Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.8 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.9 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures, including luminaire support components.
b. Faulty operation of luminaires and accessories.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

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. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. Bulb shape complying with ANSI C79.1.

G. CRI of minimum 80. CCT of 4100 K.

H. L70 lamp life of 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Nominal Operating Voltage: 277 V ac.

L. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

M. Source Limitations:

1. Obtain luminaires from single source from a single manufacturer.
2. For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.2 LUMINAIRE TYPES

A. Area and Site:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Cooper Lighting Solutions; Signify North America Corp.
3. Juno Lighting Group by Schneider Electric.

4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Luminaire Shape: As indicated on lighting schedule.
6. Mounting: Building.
7. Luminaire-Mounting Height: As indicated on drawings.
8. Distribution: As indicated on lighting schedule.
9. Housings:

    a. Extruded-aluminum housing and heat sink.
    b. Powder-coat painted finish.

2.3 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

    a. "USE ONLY" and include specific lamp type.

b. Lamp diameter, shape, size, wattage and coating.
c. CCT and CRI for all luminaires.

2.4 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

2.5 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, 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 luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, and] canopy ceilings for suitable conditions where luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533.13 "Conduits for Electrical Systems" for wiring connections and wiring methods.

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533.13 "Conduits for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Photoelectric Control Operation: Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

   a. IES LM-5.
   b. IES LM-50.
   c. IES LM-52.
   d. IES LM-64.
   e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of Architect.

END OF SECTION 265619

SECTION 270500 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Basic Communication Requirements specifically applicable to Division 27 sections, in addition to Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

A. All Division 27 section noted included in the Project Manuals.

1.3 REGULATORY REQUIREMENTS

A. Products requiring communications connection: listed and classified by underwriters laboratories, as suitable for the purpose specified and indicated.

1.4 DEFINITIONS

A. 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.

B. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

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

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

E. Finished Spaces: Spaces other than mechanical, plumbing and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, space above ceilings, unexcavated spaces, crawl spaces, and tunnels.

F. Furnish: Contractor shall supply (purchase) item and turn over to others for installation

G. Install: Others shall purchase item and the contractor shall place item in position for service and or use

H. Provide: Contractor shall furnish (purchase) and completely install item

I. Owner: Binghamton University

J. Salvage: Remove unused existing equipment where accessible and offer salvage material to the owner. Owner shall have first right of refusal of salvageable materials removed from the building. Materials not claimed by the owner shall become the property of the contractor. The contractor shall dispose of material not retained by the owner in a lawful and legal manner away from the site.

K. Storage: To provide a safe warehousing location to protect equipment and components that are to be implemented as part of the project. This includes but not limited to existing items to be relocated by the owner/contractor and items purchased by the owner/contractor.

1.5 PERFORMANCE

A. All work shall be performed in cooperation with the Owner, Architect and other separate contractors. The contractor shall coordinate work with the construction schedule established by the Owner and Architect, and shall immediately report any delays in materials receipt including circumstances causing the delays.

1.6 SUBMITTALS

A. Refer to Division 01
   1. Submittal procedures.
   2. Shop Drawings and Samples.
   3. Submittal procedures.
   4. Coordination Drawings

B. Product Data: For products listed under Part 2 of Division 27 technical specifications

C. Coordination Drawings: Provide drawings to include but not limited to:
   1. Location of access panel and door in ceilings, walls and floors
   2. Drawings to coordinate space above ceilings with other trades.
   3. Drawings coordinating light fixtures
   4. Drawings coordinating sprinklers
   5. Drawings coordinating ductwork
   6. Drawings coordinating piping
   7. Drawings coordinating equipment rooms noting, equipment pads, equipments, piping, ductwork, starters, etc.
   8. Provide plans, sections and wall elevations for all mechanical and equipment rooms.

D. Submit to architect/engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.

E. Submit the number of copies which the contractor requires, plus three copies which will be retained by the architect/engineer.

F. Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information specific to this project. Submittals that are not properly marked with all pertinent information identified will be returned.

G. Submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to the architect/engineer for product data.

H. Product data: published literature: indicate dimensions, weights, capacities, ratings, gages and finishes of materials, electrical characteristics and connection requirements.

I. Shop drawings: indicate assembly, dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics and connection requirements.

J. Manufacturer's instructions: include installation instructions.

K. Maintenance data: include instructions for lubrication, replacement parts, motor and drive replacement, spare parts lists, and wiring diagrams.

L. In addition, the submittal shall bear the project name, the contractor's name, the date reviewed by the contractor, the contractor's control number (if applicable), and a stamp with the contractor's signature certifying that the item has been reviewed and it complies with the requirements of the contract documents.

Any submittals not clearly marked as indicated above will be returned to the contractor for resubmission.

1.7 CLOSEOUT SUBMITTALS

A. Provide 3-ring binder with the following items to be used as facility Operation and Maintenance Manual
   1. Product Date: Provide one copy of final approved product data for products listed under Part 2 of Division 27 technical specifications.
   2. Manufacturer's instructions: Including installation instructions.
   3. Manufacturer's data: Include instructions for lubrication, replace parts, motor and drive replacement, spare parts list, and wiring diagrams.

1.8 SUBSTITUTIONS

A. Submittal of substitute equipment performance data shall be made in strict adherence to the requirements set forth in Section Division 01 and in Instructions to Bidders.

1.9 SEQUENCING AND SCHEDULING

A. Coordinate communication equipment installation with other building components.

B. Arrange for openings in building structure during progress of construction to allow for communication installations.

C. Sequence, coordinate, and integrate installations of communication materials and equipment for efficient flow of the Work.

D. Coordinate requirements for access panels and doors if communication items requiring access are concealed behind finished surfaces.

1.10 QUALITY ASSURANCE

A. Furnish and install necessary equipment and materials required to provide a complete communication system as shown on the Drawings.

B. System shall be in place tested (as specified), inspected and approved by all authorities having jurisdiction (where applicable).

C. Materials furnished and installations made under this specification shall conform to applicable requirements of the codes, regulations and standards described herein, unless specifically described otherwise.

D. If any codes, standards or regulations conflict, the most stringent shall apply.

E. Systems shall comply with the latest version and associated references standards of the following codes:
   1. Systems shall comply with the latest version and associated references standards of the following codes:
      a. 2020 Building Code of New York State
      b. 2020 Energy Conservation Construction Code of New York State
      c. 2020 Existing Building Code of New York State
      d. 2020 Fire Code of New York State
      e. 2020 Fuel Code of New York State
      f. 2020 Plumbing Code of New York State
      g. 2020 Mechanical Code of New York State
      h. 2020 Property Maintenance Code of New York State
      i. 2020 Residential Code of New York State
   2. Systems shall comply with the latest version of the following codes referenced standards:
      a. NFPA -13 – 2016 Installation of Sprinklers
      b. NFPA 14 – 2016 Installation of Standpipes And Hose Systems
      c. NFPA 20 – 2016 Installation of Stationary Pumps For Fire Protection
      d. NFPA 70 – 2017 National Electrical Code
      e. NFPA 72 – 2016 National Fire Alarm and Signaling Code
      f. NFPA 101 – 2018 Life Safety Code
      g. NFPA 110 – 2016 Emergency and Standby Power Systems
      h. Others as Identified

F. Materials and equipment installations shall comply with standards of:
   1. National Fire Protection Agency (NFPA).
   2. Local Utilities.
   3. Owner's Insurance Underwriters.
   4. Applicable Government Agencies and Departments.
   5. Underwriters Laboratory (UL).
   6. Federal and State Occupational Safety and Health Act (OSHA).
   7. Local Municipality.
   8. Local Fire Department.
   9. American Gas Association (AGA).

10. ANSI - American National Standards Institute.
11. ASTM Regulations and Standards for pipe, fittings, pressure vessels, testing and insulation.
12. Conformance with the applicable codes, rules and regulations of the State of New York, NYCRR, Code Rule 4 and Code Rule 14, pertaining to boilers, gas and oil burners, controls and protective devices.
13. AWWA American Water Works Association.
14. Electrically powered equipment shall comply with the National Electric Code (NEC) and shall be UL listed for the intended usage.

G. Interpretations
1. The Engineer shall provide advisory interpretations to the code regulations as requested by the contractor during construction.
2. The Department of State are the "Authorities having Jurisdiction" Construction must comply with their requirements. Work discovered not to be in compliance to the Authorities interpretation of the code regulations shall be corrected by the contractor at no additional cost to the owner.
3. The Department of State code interpretations and construction requirements shall supersede that of the Engineer.

H. Manufacturer qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

I. Approved Manufacturers:
1. A listed approved manufacturer does not relieve or relax any specification requirements.
2. Manufactures listed in the specifications and/or under addendum still must fully comply with the technical description as described in the project documents.
3. Inferior manufacturers standard offerings of products will not be accepted in lieu of the specified product.
4. The Architect/Engineer shall make the final judgment in determining if a product meets the full intent of the specifications.

1.11 CONNECTIONS

A. Furnish and install utilities serving equipment which is to be furnished by others in accordance with the sizes and locations shown on the drawings complete with final connections including provisions for shut-off and adapters as required.

B. Furnish and install required conduit and fittings as noted or specified.

C. Provide disconnects at each unit.

1.12 STRUCTURAL SUPPORTS

A. Furnish and install brackets and/or supports for the communication installations in excess of building structure as shown on drawings. Where detail is not shown, submit shop drawings of intended construction for approval.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Deliver conduits 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.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

D. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.14 COORDINATION

A. Layout of equipment, conduits, etc. is diagrammatic. Check project drawings prior to making installations for interferences with other trades. Should the contractor find such interferences, he shall be responsible for coordinating his work with the other responsible trades. Owner reserves the right to make reasonable changes prior to "roughing-in" without added expense. Dimensions shown are subject to verification of exact site conditions.

B. Refer to reflected ceiling plans, structural drawings and architectural drawings and coordinate communication installations with ceiling patterns, lighting layouts, building structural members, etc. Coordinate the communication installations with the work of others engaged in the installation to preclude the possibility of interference with communication installations shown on the drawings.

C. Arrange for spaces, chases, slots, and openings in building structure during progress of construction, to allow for communication installations.

D. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

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

F. Equipment configuration and layout has been developed on the ‘basis of design equipment’ noted in the equipment schedules. Final placement and layout of the equipment in the mechanical and electrical rooms shall be coordinated by the contractor based on the approved submittals to achieve recommended equipment clearances as required by the equipment manufacturer and maintenance clearances. The contractor shall be required to develop equipment room coordination plans noting the location of the equipment, piping, and other major components in the mechanical room prior to installation. Coordination drawings shall be submitted for approval.

1.15 PROJECT CONDITIONS

A. Contract Drawings are in part diagrammatic, intended to convey to the Contractor for the Communication Work, the scope of work and indicate general arrangement of equipment and outlets. Follow these drawings in laying out the work. Verify spaces in which the work will be installed.

B. Verify location of existing utilities before proceeding with the work.

C. Proposed conduit routing to match existing materials being connected into unless noted otherwise.

D. Verify scope of work: Contractor shall visit the job site prior to submitting a bid to ascertain existing field conditions and to determine the scope of the work, and to become familiar with the existing conditions that will affect his work and, therefore, the bid. Additional cost resulting from the contractor's failure to verify the scope of the work shall be the contractor's responsibility and shall be paid by the contractor.

E. Erect and maintain temporary partitions to prevent spread of dust, odors, and noise to permit continued owner occupancy throughout the building.

F. Work areas are to be kept free of debris at all times and are to be left broom clean at the end of each working day.

G. Adjacent areas are to be protected from dust and debris.

H. Do not close or obstruct egress width to any building or site exit.

I. Contractor shall obtain and pay for required permits from authorities.

J. Conform to applicable code for the work described within the construction documents. Base bid amount shall include additional work required by the authorities having jurisdiction pertaining to the completion of this project.

K. Contractors shall follow owner's safety requirements during construction.

L. Conform to owner's safety procedures if hazardous or contaminated materials are discovered.

M. The owner shall direct the contractor where to store salvaged items, equipment and materials removed from the work area.

N. The owner shall direct the contractor where construction materials, furniture and equipment to be installed shall be staged and stockpiled during construction.

O. The work specified herein and indicated on drawings shall be completed, tested and made ready for operation prior to turn over to the owner. Unless specifically indicated, materials and equipment shall be new and first class quality.

1.16 SYSTEMS

A. The contractor shall be responsible to provide complete and operable systems, including operational properties to the extent necessary to link multiple components of a system together and to interface with other systems.

1.17 BASIS OF DESIGN EQUIPMENT

A. Drawings equipment schedules. Add the following general note
   1. Manufacturer and Model number of equipment included in schedule is the basis of design for project.
   2. Adjustment shall be made by the contractor for equipment other than the bases of design to comply the installed equipment manufacturer's requirements.

B. Project Manual
   1. Manufacturers
      a. Manufacturer and Model number of equipment included in specifications is the basis of design for project.
      b. Adjustment shall be made by the contractor for equipment other than the bases of design to comply the installed equipment manufacturer's requirements.

1.18 SALVAGED ITEMS

A. Remove all unused existing equipment where accessible and offer all salvage material to the owner.

B. Owner shall have first right of refusal of all salvageable materials removed from the building.

C. Materials not claimed by the owner shall become the property of the contractor.

D. The contractor shall dispose of all material not retained by the owner in a lawful and legal manner away from the site

E. Items salvaged shall be moved and stored in a location as directed by the owner.

F. The owner shall direct the contractor where to store salvaged items, equipment and materials removed from the work area.

G. At the start of the project, the Owner and contractor shall survey the building and identify all items to be salvaged and turn over to the owner

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials and equipment shall be in strict accordance with the parameters hereinafter specified and as shown on the drawings.

B. Materials and equipment furnished/provided shall be new unless noted otherwise.

2.2 ACCESSORIES

A. It is the intent of this specification that systems and equipment shall be complete with all accessories required to insure a complete system.

2.3 ELECTRICAL CONNECTIONS

A. Electrical components provided shall be in compliances and sized in accordance with the National Electrical Code NFPA 70.

B. Communication equipment shall be UL listed

2.4 MANUFACTURERS

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

1. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
2. Basis of Design: Subject to compliance with requirements, provide products by the manufacturers specified.

PART 3 - EXECUTION

3.1 DEMOLITION

A. Refer to specification Sections for "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove systems, equipment, and components indicated to be removed.

1. Conduit to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining conduit with same or compatible piping material.
2. Conduit to Be Abandoned in Place: Drain piping and cap or plug conduit with same or compatible piping material.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. The layout of conduit, equipment etc. is diagrammatic in nature. Not all components are shown on the drawings.

D. Contractor shall notify the owner in advance of any shutdown necessary of the existing systems. Minimum notification time shall be 72 hours.

E. Do not disable or disrupt building systems without 3 days prior written notice to owner.

F. Provide temporary services to maintain existing systems in service during construction.

G. Abandoned and inactive components shall be removed back to their active main or area and terminated. Including but not limited to the following conduit, raceways, or other system components shall be removed.

3.2 CUTTING AND PATCHING

A. The contractor shall be responsible for cutting and patching as described herein or as indicated on the drawings. The contractor shall be responsible for coordinating his cutting and patching requirements with the other trades.

B. Connection of new services to existing shall be in a neat and approved manner with disturbed services restored to original condition.

C. Do cutting and patching work as noted and as necessary for the installation of the communication work.

D. Cut, channel, chase, and drill ceilings, and other surfaces necessary for communication installations. Perform cutting by skilled mechanics of trade involved.

E. Repair cut surfaces to match adjacent surfaces.

F. The contractor is responsible for cutting and patching of existing work to facilitate and to conceal the work described within these documents. Surfaces to be patched shall be finished to match the existing surface. Owner has final say as to the acceptability of the finished patched work.

G. Core drill openings in concrete floors necessary for systems

3.3 INSTALLATION

A. Unless otherwise noted or specified, materials and equipment shall be installed in strict accordance with the manufacturer’s instructions and recommendations.

B. Do not scale Drawings.

C. The location of new conduit and raceways are approximate. The exact location of conduit and equipment shall be determined in the field to:
   1. Provide manufacturer’s recommended clearances.
   2. Avoid interference with existing conditions.
   3. Avoid interference with new work of other trades.

D. Provide additional fittings as required to effect required changes in direction and elevation.

E. Provide additional offsets and fittings as required to accommodate obstructions that are to remain.

F. Do not cut any structural building member without permission of the Architect.

G. Provide interlocking controls for air handlers with the building fire alarm system. Upon activation of the building fire alarm system, the fans within the air handlers shall be shut down. Coordinate installation with the manufacture of the building fire alarm system.

H. The actual relative locations of conduit, receptacles, equipment, etc. shall be adjusted during construction according to final placement of equipment.

I. The contractor shall provide required offset, transitions, fittings, and components etc. as required to complete the installation of the systems in order to conform to the building structure and existing building systems. This shall include but not be limited to piping systems, duct systems, etc.

J. Systems serving other areas of owner's facilities shall remain active and fully functional throughout the duration of the project for Owner occupied areas. System shutdowns shall be coordinated with owner's field representative as required to accomplish system tie in, system extension and/or system removal work.

K. Work on existing systems that are to remain active during construction shall be coordinated with owner's field representative.

L. Contractor is responsible for verification of all dimensions.

M. The layout of conduit, boxes, receptacles, equipment etc. is diagrammatic in nature. Provide required offsets to accommodate obstructions and final system placement.

N. Unless noted otherwise, system components shall not be exposed. Conduits and raceways shall be concealed within the ceilings and wall structures.

O. The drawings do not show all off sets or fittings required for installation. Schematic diagrams convey the configuration and system components, but not all of the fittings required for the final installation are shown.

3.4 PROTECTION

A. All materials, equipment and accessories shall be suitably protected and covered during construction.

B. Damage responsibility: The contractor shall be responsible for any loss or damage caused by him or his workmen to the facility, building surfaces or equipment during the course of construction, and shall be fully responsible for repairing or replacing as required to insure restoration to original condition.

C. Damaged items: Where items scheduled for reuse are found to be in damaged condition, the contractor shall call the attention of the owner to such items and receive further instructions

prior to removal. Items damaged during removal shall be repaired or replaced by the contractor at no additional cost to the owner.

D. Repair damages: Promptly repair damage to adjacent facilities by demolition operations at no cost to the owner.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install 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.

3.6 PAINTING AND FINISHING

A. Painting of systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 CEILING SYSTEM NOTES

A. Plaster frames shall be provided for equipment installed in plaster or gypsum board ceiling.

B. Lay-in frames shall be compatible with the ceiling grid system. Note where standard and micro-grid ceiling systems are to be installed throughout the project area. Coordinate equipment frames accordingly.

3.8 FIRE PROTECTION

A. Fire rated assemblies: Provide fire retardant NRTL approved sealant on raceway penetrations of fire rated ceilings, partitions, walls, and structural slabs. It shall be the responsibility of the Contractor to verify locations of such fire rated partitions, walls and structural slabs prior to submitting bid.

B. Fire rated assemblies: Fire rated assemblies to be penetrated shall be installed with applicable through-penetration fire-stop system determined by U.L. classification.

C. Fire alarm system modification shall be coordinated with central security before making any alterations.

3.9 ACCESS DOORS – FINISHED SURFACES

A. Provide wall, ceiling or floor access doors at locations where equipment, data and cable raceways, j-boxes, and other components needing access that are located within concealed spaces. Typical for walls, floor and ceilings.

B. Provide wall, ceiling or floor access doors where equipment and raceways are not exposed. Doors shall be flushed mounted with key lock, with full piano hinge sized to adequately access components and raceways.

C. Access doors shall be flushed mounted with key lock to Owners keying system, with full piano hinge sized to adequately access components and not smaller than 12”x12”.

D. Access doors shall be rated for the assembly they are to be installed in.

E. Doors shall be polished stainless steel finished unless noted otherwise

F. Refer to division 8

3.10 ADA WALL MOUNTING HEIGHT

A. Wall mounted components that require adjustment or manual operation shall be mounted so the top of the unit is 40” above the finish floor or below.

B. Wall mounted sensors that do not require adjustment or manual operations shall be mounted so the top of the unit is 54” above the finish floor or below.

C. Wall mounted receptacles shall be mounted a minimum of 18” above finish floor to the center of the box.

3.11 INSPECTIONS

A. The Contractor shall have:
   1. Required local or municipal inspection processed and present Owner with certificate indicating approval of such governing bodies.

END OF SECTION 270500

SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Selection and installation of communications busbars.
   2. Selection and installation of communications bonding conductors.

1.2 DEFINITIONS

A. BBC: Backbone bonding conductor, for connecting multiple TBBs serving the same floor.

B. PBB: Primary bonding busbar, located in main distribution frame room, ideally near electrical service entrance.

C. RBB: Rack bonding busbar, located in equipment cabinets and racks.

D. SBB: Secondary bonding busbar, located in intermediate distribution frame rooms.

E. TBB: Telecommunications bonding backbone, for connecting SBBs to PBB.

F. TBC: Telecommunications bonding conductor, for connecting PBB to intersystem bonding termination device or busbar at electrical service entrance.

G. TEBC: Telecommunications equipment bonding conductor, for connecting RBBs to SBBs or PBB.

H. UBC: Unit bonding conductor, for connecting individual communications equipment to RBBs or SBBs.

1.3 ACTION SUBMITTALS

A. Shop Drawings:
   1. For communications equipment room signal reference grid.
   2. Include plans, elevations, sections, details, and attachments to other work.

B. Field Quality-Control Submittals:
   1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation[and testing] instructions issued to Installer by manufacturer for the following:
   1. Installing wire connector on conductor.

2. Recommended torque values.

1.5 CLOSEOUT SUBMITTALS

A. Record Documentation: Project record documents in accordance with Section 017839 "Project Record Documents" must include locations of PBB and SBBs, and routing of TBC, TBBs, and BBCs.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.

B. Inspect test results of grounding system measured at point of TBC connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of TBC only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF COMMUNICATIONS BUSBARS

A. Unless otherwise indicated in this Section or on Drawings, provide products specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. PBB:
1. Dimensions: 1/4 inch thick by 4 inch high.
2. Stand-Off Distance: 4 inch>.

C. SBB:
1. Dimensions: 1/4 inch thick by 4 inch high.
2. Stand-Off Distance: 4 inch.

3.3 SELECTION OF COMMUNICATIONS BONDING CONDUCTORS

A. Unless otherwise indicated in this Section or on Drawings, provide products specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Communications Busbar Connections:
1. TBC: Not smaller than 1/0 AWG and no smaller than largest TBB.

2. TBB: Not smaller than 2 kcmil per linear ft of conductor length, but not larger than 750 kcmil, unless otherwise indicated on Drawings.
3. BBC: Not smaller than largest TBB to which it is connected unless otherwise indicated on Drawings.
4. TEBC: Not smaller than 2 AWG unless otherwise indicated on Drawings. Provide bolted connectors.
5. UBC: Not smaller than 6 AWG unless otherwise indicated on Drawings. Provide bolted connectors.
6. Bonding Conductors to Structural Steel: Not smaller than 6 AWG unless otherwise indicated on Drawings. Provide bolted clamp connectors.

C. Cable Tray Connections:
1. Cable Tray Equipment Grounding Conductor: 8 AWG.
2. Cable Tray Bonding Jumper: If not supplied by cable manufacturer, provide bonding jumper not smaller than 10 AWG and not longer than 12 inch. If jumper is wire, it must be terminated with lug having one hole and standard barrel for one crimp. If jumper is flexible braid, it must be terminated with one- or two-hole ferrule. Attach with bonding screw or connector provided by cable tray manufacturer.

D. Underground Connections: Not smaller than 2 AWG. Provide welded connectors, except bolted connectors may be used in handholes or manholes and as otherwise indicated on Drawings.

3.4 INSTALLATION OF BONDING FOR COMMUNICATIONS

A. Comply with manufacturer's published instructions.

B. Reference Standards:
1. Bonding of Communications: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with BICSI N3.
2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:
1. Busbars:
a. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 12 inch above finished floor unless otherwise indicated.
b. 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.
2. Conductors:
a. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
b. Assemble wire connector to conductor, complying with manufacturer's published instructions and as follows:
1) Use crimping tool and die specific to connector.
2) Pretwist conductor.
3) Apply antioxidant compound to bolted and compression connections.
c. Install in straightest and shortest route between origination and termination point, and no longer than required. Bend radius must not be smaller than 10 times diameter of conductor. No single bend may exceed 90 degrees.
d. Install without splices.
e. Support conductors at not more than 36 inch intervals.

f. Outside telecommunications rooms, install conductors in metric designator 21 (trade size 3/4) PVC-80 conduit until conduit enters telecommunications room. Install bonding conductors in EMT-A or EMT-SS when routed through plenum. Do not install bonding conductors in EMT-S unless otherwise indicated on Drawings.
   1) If bonding conductor must be installed in EMT-S or other ferrous metallic raceway, bond conductor to raceway using grounding bushing that complies with Section 270528 "Pathways for Communications Systems," and bond both ends of raceway to SBB.

3. Provide TBC and terminate ends to PBB and intersystem bonding busbar at electrical service entrance in accordance with Section 250.94, "Bonding for Communication Systems," of NFPA 70.
4. Busbar Interconnections: Bond SBBs to PBB with TBBs. If more than one TBB is installed, bond TBBs together BBCs where required by TIA-607.
5. Structural Steel: Where structural steel of steel frame building is readily accessible within room or space, bond each SBB and PBB to vertical steel of building frame.
6. Communications Enclosures: Bond metallic enclosures of telecommunications equipment with UBCs to nearest SBB or PBB.
7. Equipment Racks: Bond metallic components of enclosures to RBB using UBCs. Provide vertically mounted RBB if not provided by enclosure or rack manufacturer. Bond RBB to SBB with TEBC. Power connection must comply with NFPA 70; equipment grounding conductor in power cord of cord- and plug-connected equipment must be considered supplemental to bonding requirements in this Section.
8. Shielded Cable: Bond shield of shielded cable to SBB in communications rooms and spaces. Comply with TIA-568.1 and TIA-568.2 when grounding shielded balanced twisted-pair cables.
9. Primary Protector: Bond to PBB with insulated bonding conductor.
10. Electrical Power Panelboards: Where electrical panelboards for communications equipment are located in same room or space, bond each ground bar of panelboard to SBB.
11. Cable Trays: Provide continuous electrical path by installing bonding clips and jumpers. Bond each end to nearest SBB.
12. Ladder Racks: Provide continuous electrical path by installing bonding clips and jumpers. Bond each end to nearest SBB.
13. Access Floors: Bond metal parts of access floors to SBB.

3.5 IDENTIFICATION

A. Comply with Section 270553 "Identification for Communications Systems."

B. Labels must be preprinted or computer-printed type.
1. Label PBB(s) with "ts-PBB," where "ts" is telecommunications space identifier for location of PBB.
2. Label SBB(s) with "ts-SBB," where "ts" is telecommunications space identifier for location of SBB.
3. Label TBC, TBBs, and BBCs at attachment points with legend: "WARNING! COMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.6 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench according to manufacturer's published instructions.
   2. Test bonding connections of system using AC earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing PBB or SBB, using process recommended by BICSI N1. Conduct tests with facility in operation.
      a. Measure resistance between PBB and electrical service intersystem termination point. Maximum acceptable value is 100 mΩ.
         1) If measured resistance from electrical service equipment to ground exceeds 5 Ω, notify Architect and include recommendations to reduce resistance to ground.
      b. Measure resistance between SBBs and PBB. Maximum acceptable value is 100 mΩ.

B. Nonconforming Work:
   1. Communications bonding will be considered defective if it does not pass tests and inspections.
   2. Remove and replace defective units and retest.

C. Collect, assemble, and submit test and inspection reports.

3.7 PROTECTION

A. After installation, protect busbars and conductors from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 270526

SECTION 270528 - PATHWAYS FOR COMMUNICATIONS 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. Hooks.
   4. Boxes, enclosures, and cabinets.

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid conduit.

C. IMC: Intermediate metal conduit.

D. RTRC: Reinforced thermosetting resin conduit.

1.4 ACTION SUBMITTALS

A. Product data for the following:
   1. Surface pathways
   2. Boxes, enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Pathway 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 pathway groups with common supports.
   2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
   3. Underground ducts, piping, and structures in location of underground enclosures and handholes.

B. Qualification Data: For professional engineer.

C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems; Atkore International.
2. Allied Tube & Conduit; Atkore International.
3. Southwire Company, LLC.

C. General Requirements for Metal Conduits and Fittings:
1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
2. Comply with TIA-569-D.

D. GRC: Comply with ANSI C80.1 and UL 6.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Fittings for EMT:
a. Material: Steel.
b. Type: Compression.
2. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Description: Nonmetallic raceway of circular section with manufacturer-fabricated fittings.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cantex Inc.
2. Condux International, Inc.
3. National Pipe and Plastic.
4. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

C. General Requirements for Nonmetallic Conduits and Fittings:
1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Comply with TIA-569-D.

D. RNC: Type EPC-80-PVC , complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. Rigid HDPE: Comply with UL 651A.

F. Continuous HDPE: Comply with UL 651A.

G. RTRC: Comply with UL 2515A and NEMA TC 14.

H. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.

2.3 HOOKS

A. Description: Prefabricated sheet metal cable supports for telecommunications cable.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. MonoSystems, Inc.
2. Panduit Corp.
3. Wiremold; Legrand North America, LLC.

C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with TIA-569-D.

E. stainless steel.

F. J shape.

2.4 BOXES, ENCLOSURES, AND CABINETS

A. Description: Enclosures for communications.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB, Electrification Business.
2. Crouse-Hinds; brand of Eaton, Electrical Sector.
3. Hoffman; brand of nVent Electrical plc.
4. Plasti-Bond; Robroy Industries.

C. General Requirements for Boxes, Enclosures, and Cabinets:
1. Comply with TIA-569-D.
2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
4. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
5. Gangable boxes are prohibited.

D. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

E. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.

F. Metal Floor Boxes:
1. Material: Cast metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. 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.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250 Type 3R, 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.

I. 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.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

A. Outdoors: Apply pathway products as specified below unless otherwise indicated:
1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, Type EPC-80-PVC, concrete encased.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply pathway 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. Pathway locations include the following:
a. Loading dock.
b. Mechanical rooms.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Damp or Wet Locations:GRC.

6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway, EMT.
7. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway, EMT.
8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in damp or wet locations.

C. Minimum Pathway Size: 3/4-inch trade size for copper and aluminum cables, and 1 inch for optical-fiber cables.

D. Pathway Fittings: Compatible with pathways and suitable for use and location.
1. Rigid: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use set-screw or compression, steel fittings. Comply with NEMA FB 2.10.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface pathways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:
1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.
4. NECA 101
5. NECA 102.
6. NECA 105.
7. NECA 111.

B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

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

D. Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems" for hangers and supports.

E. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

F. Complete pathway 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 two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.

I. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

J. Support conduit within 12 inches of enclosures to which attached.

K. Pathways Embedded in Slabs:
1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot intervals.
2. Arrange pathways to cross building expansion joints at right angles with expansion fittings. Comply with requirements for expansion joints specified in this article.
3. Arrange pathways to keep a minimum of 1 inch 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 nonmetallic conduit and fittings to GRC and fittings before rising above floor.

L. Stub-ups to Above Recessed Ceilings:
1. Use EMT for pathways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

M. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.

O. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.

P. 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.

Q. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

R. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.

S. Surface Pathways:
1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
2. Install surface pathway with a minimum 2-inch radius control at bend points.

3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

T. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
1. 1-1/2-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.
2. 2-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

U. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, 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 pathway-sealing fittings according to NFPA 70.

V. Install devices to seal pathway 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 pathways at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service pathway enters a building or structure.
3. Where otherwise required by NFPA 70.

W. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

X. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet. Install in each run of aboveground EMT that is located where environmental temperature change may exceed 100 deg F, and that has straight-run length that exceeds 100 feet.
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 temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
   c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F 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 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 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.

Y. Hooks:
1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
3. Hook spacing shall allow no more than 6 inches of slack. The lowest point of the cables shall be no less than 6 inches adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
4. Space hooks no more than 5 feet o.c.
5. Provide a hook at each change in direction.

Z. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements.

AA. 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 surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

BB. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

CC. 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.

DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 310000 "Earthwork" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 310000 "Earthwork."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.

b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078400 "Through-Penetration Firestop Systems."

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or 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 270528

SECTION 270529 - HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Steel slotted support systems for communication raceways.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment support assemblies.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. 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-diameter holes at a maximum of 8 inches o.c. in at least one surface.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Allied Tube & Conduit; Atkore International.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. G-Strut.

d. Unistrut; Atkore International.
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. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
7. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel clamps, hangers, 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 communications 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] [stainless 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) Cooper B-line; brand of Eaton, Electrical Sector.
      2) Empire Industries, Inc.
      3) Hilti, 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.

6. Toggle Bolts: Stainless-steel springhead type.
7. Hanger Rods: Threaded steel.

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/BICSI 568.
   3. TIA-569-D.
   4. NECA 101.
   5. NECA 102.
   6. NECA 105.
   7. NECA 111.

B. Comply with requirements in Section 0784103 "Through-Penetration Firestop Systems" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs and GRCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted [or other]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 single-bolt conduit clamps or single-bolt conduit clamps, using spring friction action for retention in support channel.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Raceway Support Methods: In addition to methods described in NECA 1, EMT and GRC may be supported by openings through structure members, according to NFPA 70.

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.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten communications 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: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Existing Concrete: Use 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 thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
   6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts or Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
   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.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 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 minimum dry film thickness of 2.0 mils.

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

END OF SECTION 270529

SECTION 270536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Wire-mesh cable tray.
   2. Cable tray accessories.
   3. Warning signs.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles on individual cable tray types for specific values for uniform load distribution, concentrated load, and load and safety factor parameters.

D. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. B-Line; a division of Eaton, Electrical Sector.
   b. G-Strut.
   c. Unistrut; a brand of Atkore International.

E. Description:

   1. Configuration: Galvanized- steel wire mesh, complying with NEMA VE 1.
   2. Width: 18 inches unless otherwise indicated on Drawings.
   3. Minimum Usable Load Depth: 4 inches.
   4. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.
   5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
   6. Class Designation: Comply with NEMA VE 1.
   7. Splicing Assemblies: Bolted type using serrated flange locknuts.

8. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

F. Materials and Finishes:

1. Steel:

a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A1008/A1008M, Grade 33, Type 2.
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish: Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2.

1) Hardware: Galvanized, ASTM B633.

e. Finish: Hot-dip galvanized after fabrication, complying with ASTM A653/A653M, G90.

1) Hardware: Galvanized, ASTM B633.

f. Finish: Electrogalvanized after fabrication, complying with ASTM B633.

1) Hardware: Galvanized, ASTM B633.

2.2 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.3 WARNING SIGNS

A. Comply with requirements for identification in Section 270553 "Identification for Communications Systems."

B. Lettering: 1-1/2-inch- high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

2.4 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays according to NEMA FG 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. Install cable trays according to NEMA FG 1.

B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Fasten cable tray supports to building structure.

D. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb. Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems."

E. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

F. Support wire-basket cable trays with trapeze hangers.

G. Support trapeze hangers for wire-basket trays with 3/8-inch- diameter rods.

H. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

I. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA FG 1. Space connectors and set gaps according to applicable standard.

J. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078400 "Through-Penetration Firestop Systems."

K. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

L. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

M. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.

N. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."

B. Cable trays with shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket.

C. Fasten cables on vertical runs to cable trays every 18 inches.

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

E. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

A. Connect raceways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
   2. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
   3. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
   4. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
   5. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
   6. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
   7. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

END OF SECTION 270536

SECTION 270553 - IDENTIFICATION FOR COMMUNICATIONS 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. Underground-line warning tape.
   2. Signs.
   3. Cable ties.
   4. Miscellaneous identification products.
   5. Labels.

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 communications identification products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 70 and TIA 606-B.

B. Comply with ANSI Z535.4 for safety signs and labels.

C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Equipment Identification Labels:
   1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Champion America.
      c. LEM Products Inc.
      d. emedco.

B. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, vinyl flexible labels with acrylic pressure-sensitive adhesive.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Ideal Industries, Inc.
      c. LEM Products Inc.
      d. Panduit Corp.
   2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating protective shields over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
   3. Marker for Labels:
      a. Permanent, waterproof black ink marker recommended by tag manufacturer.
      b. Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.

C. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Ideal Industries, Inc.
      c. LEM Products Inc.
      d. Panduit Corp.
   2. Minimum Nominal Size:
      a. 1-1/2 by 6 inches for raceway and conductors.
      b. 3-1/2 by 5 inches for equipment.
      c. As required by authorities having jurisdiction.

2.4 UNDERGROUND-LINE WARNING TAPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Ideal Industries, Inc.
   3. LEM Products Inc.

B. Tape:
   1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground 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 degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

C. Color and Printing:
1. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, and ANSI Z535.4.
2. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL-FIBER CABLE".

D. Tag, Detectable:
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 on one side with the inscription of the utility,compounded for direct-burial service.
2. Width: 3 inches.
3. Overall Thickness: 5 mils.
4. Foil Core Thickness: 0.35 mil.
5. Weight: 28 lb/1000 sq. ft..
6. Tensile according to ASTM D882: 70 lbf and 4600 psi.

2.5 SIGNS

A. Baked-Enamel Signs:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Carlton Industries, LP.
   c. Champion America.
   d. Marking Services Inc.
2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
3. 1/4-inch grommets in corners for mounting.
4. Nominal Size: 7 by 10 inches.

B. Laminated-Acrylic or Melamine-Plastic Signs:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Carlton Industries, LP.
   c. Marking Services Inc.
   d. Seton Identification Products; a Brady Corporation company.
2. Engraved legend.
3. Thickness:
   a. For signs up to 20 sq. in., minimum 1/16 inch thick.
   b. For signs larger than 20 sq. in., 1/8 inch thick.
   c. Engraved legend with black letters on white face.
   d. Self-adhesive.
   e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. HellermannTyton.
   2. Ideal Industries, Inc.
   3. Marking Services Inc.
   4. Panduit Corp.

B. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength at 73 deg F according to ASTM D638: 7000 psi.
   3. UL 94 Flame Rating: 94V-0.
   4. Temperature Range: Minus 50 to plus 284 deg F.
   5. Color: Black.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.

G. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

H. Vinyl Wraparound Labels:
1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
3. Provide label 6 inches from cable end.

I. Self-Adhesive Wraparound Labels:
1. Secure tight to surface at a location with high visibility and accessibility.
2. Provide label 6 inches from cable end.

J. Self-Adhesive Labels:
1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

K. Underground-Line Warning Tape:
1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope]exceeds 16 inches overall.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

L. Cable Ties: General purpose, except as listed below:
1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.

C. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box with self-adhesive labels containing wiring system legend.
1. System legends shall be as follows:
a. Telecommunications.

D. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation, numbered clockwise when entering room from primary egress, composed of the following, in the order listed:
1. Wiring closet designation.

2. Colon.
3. Faceplate number.

E. Equipment Room Labeling:
1. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels containing equipment designation.
2. Patch Panels: Label individual rows and outlets, starting at to left and working down, with self-adhesive labels.
3. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:
   a. Room number being served.
   b. Colon.
   c. Faceplate number.

F. Backbone Cables: Label each cable with a vinyl-wraparound label indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identically.

G. Horizontal Cables: Label each cable with a vinyl-wraparound label indicating the following, in the order listed:
1. Room number.
2. Colon.
3. Faceplate number.

H. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.

I. Instructional Signs: Self-adhesive labels.

J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Self-adhesive labels.
1. Apply to exterior of door, cover, or other access.

K. Equipment Identification Labels:
1. Indoor Equipment: Self-adhesive label.
2. Outdoor Equipment: Laminated-acrylic or melamine-plastic sign.
3. Equipment to Be Labeled:
   a. Communications cabinets.
   b. Uninterruptible power supplies.
   c. Computer room air conditioners.
   d. Fire-alarm and suppression equipment.
   e. Power distribution components.

END OF SECTION 270553

SECTION 271513 - COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Category 5e twisted pair cable.
   2. Category 6a twisted pair cable.
   3. Twisted pair cable hardware, including plugs and jacks.
   4. Cable management system.
   5. Grounding provisions for twisted pair cable.

1.2 COPPER HORIZONTAL CABLING DESCRIPTION

A. Horizontal cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
   1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
   2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
   3. Bridged taps and splices shall not be installed in the horizontal cabling.

B. A work area is approximately 100 sq. ft., and includes the components that extend from the equipment outlets to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings.
   1. System Labeling Schedules:
      a. Electronic copy of labeling schedules, in software and format selected by Owner.
      b. Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
   2. Cabling administration Drawings and printouts.
   3. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment.

C. Twisted pair cable testing plan.

D. Field Quality-Control Submittals:
   1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, installation supervisor, and field inspector.

B. Product Certificates: For each type of product.

C. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On USB media.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   1. Installation Supervision: Installation shall be under the direct supervision of Technician, who shall be present at all times when Work of this Section is performed at Project site.
   2. Testing Supervisor: Currently certified by BICSI to supervise on-site testing.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.
   1. Testing Agency's Field Supervisor: Currently certified by BICSI.

1.7 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. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
   1. Communications, Non-Plenum Rated:
      a. Type CMP or Type CMR in listed plenum or riser communications raceway.

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-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

C. RoHS compliant.

2.3 CATEGORY 5e TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 100 MHz.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following or substitution as approved by engineer:
   1. Belden Inc.
   2. Berk-Tek, a Leviton Company.
   3. CommScope, Inc.
   4. General Cable; Prysmian Group North America.

C. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.

D. Conductors: 100-ohm, 24 AWG solid copper.

E. Shielding/Screening: Unshielded twisted pairs (UTP)

F. Cable Rating: Riser.

G. Jacket: thermoplastic, color to be approved by owner.

2.4 CATEGORY 6a TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 6a cable at frequencies up to 500 MHz.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following or substitution as approved by engineer:
   1. 3M.
   2. Berk-Tek, a Leviton Company.
   3. CommScope, Inc.
   4. General Cable; Prysmian Group North America.

C. Standard: Comply with TIA-568-C.2 for Category 6a cables.

D. Conductors: 100-ohm, 23 AWG solid copper.

E. Shielding/Screening: Unshielded twisted pairs (UTP).

F. Cable Rating: Riser.

G. Jacket: thermoplastic, color to be approved by owner.

2.5 TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.

B. General Requirements for Twisted Pair Cable Hardware:
1. Comply with the performance requirements of [Category 5e] [Category 6] [Category 6a].
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

C. Source Limitations: Obtain twisted pair cable hardware from single source from single manufacturer.

D. Connecting Blocks:
1. 110-style IDC for Category 5e.
2. 110-style IDC for Category 6a.
3. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.

E. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
1. Number of Terminals per Field: One for each conductor in assigned cables.

F. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.
1. Features:
   a. Universal T568A and T568B wiring labels.
   b. Labeling areas adjacent to conductors.
   c. Replaceable connectors.
   d. 24 or 48 ports.
2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.

G. Patch Cords: Factory-made, four-pair cables in 48-inch lengths; terminated with an eight-position modular plug at each end.
1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

H. Plugs and Plug Assemblies:
1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.

2. Standard: Comply with TIA-568-C.2.
3. Marked to indicate transmission performance.

I. Jacks and Jack Assemblies:
1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
2. Designed to snap-in to a patch panel or cover plate.
3. Standard: Comply with TIA-568-C.2.
4. Marked to indicate transmission performance.

J. Cover Plate:
1. Two port, vertical single gang cover plates designed to mount to single gang wall boxes.
2. Plastic Cover Plate: High-impact plastic. Coordinate color with Section 260533 "Raceway and Boxes for Electrical Systems."
3. Metal Cover Plate: Stainless steel, complying with requirements in Section 260533 "Raceway and Boxes for Electrical Systems."
4. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.
   a. Flush mounting jacks, positioning the cord at a 45-degree angle.

K. Legend:
1. Machine printed, in the field, using adhesive-tape label.
2. Snap-in, clear-label covers and machine-printed paper inserts.

2.6 CABLE MANAGEMENT SYSTEM

A. Description: Computer-based cable management system, with integrated database and graphic capabilities.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following or substitution as approved by engineer:
1. Telsoft Solutions.
2. iTRACS Corporation.

C. Document physical characteristics by recording the network, TIA details, and connections between equipment and cable.

D. Information shall be presented in database view, schematic plans, or technical drawings.
1. AutoCAD drawing software shall be used as drawing and schematic plans software.

E. System shall interface with the following testing and recording devices:
1. Direct upload tests from circuit testing instrument into the personal computer.
2. Direct download circuit labeling into labeling printer.

PART 3 - EXECUTION

3.1 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. Routing: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables, except in unfinished spaces.
   1. Install plenum cable in environmental air spaces, including plenum ceilings.
   2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

D. General Requirements for Cabling:
   1. Comply with TIA-568-C.1.
   2. Comply with BICSI's Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
   3. Install 110-style IDC termination hardware unless otherwise indicated.
   4. Do not untwist twisted pair cables more than 1/2 inch from the point of termination to maintain cable geometry.
   5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
   6. 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.
   7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
   8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
   9. 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.
   10. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
   11. In the communications equipment room, install a 10-foot-long service loop on each end of cable.
   12. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

E. Group connecting hardware for cables into separate logical fields.

F. Separation from EMI Sources:
   1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.

3.2 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with "Firestopping Systems" Article in BISCI's "Telecommunications Distribution Methods Manual."

3.3 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."

C. Comply with TIA-607-B and NECA/BICSI-607.

D. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.

E. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.4 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

B. Equipment grounding conductors.

C. Cable and Wire Identification:
   1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
   2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
   3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
   4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.

a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

D. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:
1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.5 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by owner representative.

B. Tests and Inspections:
1. Visually inspect 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-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test twisted pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.

D. Nonconforming Work:
1. End-to-end cabling will be considered defective if it does not pass tests and inspections.
2. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

E. Collect, assemble, and submit test and inspection reports.

3.6 MAINTENANCE

A. Software Service Agreement:
1. Technical Support: Beginning at Substantial Completion, verify that software service agreement includes software support for two years.
2. 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. Verify that upgrading software includes operating system and new or revised licenses for using software.

a. Upgrade Notice: No fewer than 30 <Insert number> days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 271513

SECTION 280500 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Basic Electronic safety and security Requirements specifically applicable to Division 28 sections, in addition to Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

A. All Division 28 sections noted in the Project Manual.

1.3 REGULATORY REQUIREMENTS

A. Products requiring Electronic Safety and Security connection: listed and classified by underwriters laboratories, as suitable for the purpose specified and indicated.

1.4 DEFINITIONS

A. 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.

B. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

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

D. Finished Spaces: Spaces other than mechanical, plumbing and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, space above ceilings, unexcavated spaces, crawl spaces, and tunnels.

E. Furnish: Contractor shall supply (purchase) item and turn over to others for installation

F. Install: Others shall purchase item and the contractor shall place item in position for service and or use

G. Provide: Contractor shall furnish (purchase) and completely install item

H. Owner: Binghamton University

I. Salvage: Remove unused existing equipment where accessible and offer salvage material to the owner. Owner shall have first right of refusal of salvageable materials removed from the

building. Materials not claimed by the owner shall become the property of the contractor. The contractor shall dispose of material not retained by the owner in a lawful and legal manner away from the site.

J. Storage: To provide a safe warehousing location to protect equipment and components that are to be implemented as part of the project. This includes but not limited to existing items to be relocated by the owner/contractor and items purchased by the owner/contractor.

1.5 PERFORMANCE

A. All work shall be performed in cooperation with the Owner, Architect and other separate contractors. The contractor shall coordinate work with the construction schedule established by the Owner and Architect, and shall immediately report any delays in materials receipt including circumstances causing the delays.

1.6 SUBMITTALS

A. Refer to Division 01
   1. Submittal procedures.
   2. Shop Drawings and Samples.

B. Product Data: For products listed under Part 2 of Division 28 technical specifications

C. Submit to architect/engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.

D. Submit the number of copies which the contractor requires, plus three copies which will be retained by the architect/engineer.

E. Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information specific to this project. Submittals that are not properly marked with all pertinent information identified will be returned.

F. Submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to the architect/engineer for product data.

G. Product data: published literature: indicate dimensions, weights, capacities, ratings, gages and finishes of materials, electrical characteristics and connection requirements.

H. Shop drawings: indicate assembly, dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics and connection requirements.

I. Manufacturer's instructions: include installation instructions.

J. Maintenance data: include instructions for lubrication, replacement parts, motor and drive replacement, spare parts lists, and wiring diagrams.

K. In addition, the submittal shall bear the project name, the contractor's name, the date reviewed by the contractor, the contractor's control number (if applicable), and a stamp with the

contractor's signature certifying that the item has been reviewed and it complies with the requirements of the contract documents.

L. Any submittals not clearly marked as indicated above will be returned to the contractor for resubmission

1.7 CLOSEOUT SUBMITTALS

A. Provide 3-ring binder with the following items to be used as facility Operation and Maintenance Manual
   1. Product Date: Provide one copy of final approved product data for products listed under Part 2 of Division 28 technical specifications.
   2. Manufacturer’s instructions: Including installation instructions.
   3. Manufacturer’s data: Include instructions for lubrication, replace parts, motor and drive replacement, spare parts list, and wiring diagrams.

1.8 SUBSTITUTIONS

A. Submittal of substitute equipment performance data shall be made in strict adherence to the requirements set forth in Section Division 01and in Instructions to Bidders.

1.9 SEQUENCING AND SCHEDULING

A. Coordinate electronic safety and security equipment installation with other building components.

B. Arrange for openings in building structure during progress of construction to allow for electronic safety and security installations.

C. Sequence, coordinate, and integrate installations of electronic safety and security materials and equipment for efficient flow of the Work.

D. Coordinate requirements for access panels and doors if electronic safety and security items requiring access are concealed behind finished surfaces.

1.10 QUALITY ASSURANCE

A. Furnish and install necessary equipment and materials required to provide a complete electronic safety and security system as shown on the Drawings.

B. System shall be in place tested (as specified), inspected and approved by all authorities having jurisdiction (where applicable).

C. Materials furnished and installations made under this specification shall conform to applicable requirements of the codes, regulations and standards described herein, unless specifically described otherwise.

D. If any codes, standards or regulations conflict, the most stringent shall apply.

E. Systems shall comply with the latest version and associated references standards of the following codes:
   1. Systems shall comply with the latest version and associated references standards of the following codes:
      a. 2020 Building Code of New York State
      b. 2020 Energy Conservation Construction Code of New York State
      c. 2020 Existing Building Code of New York State
      d. 2020 Fire Code of New York State
      e. 2020 Fuel Code of New York State
      f. 2020 Plumbing Code of New York State
      g. 2020 Mechanical Code of New York State
      h. 2020 Property Maintenance Code of New York State
      i. 2020 Residential Code of New York State
   2. Systems shall comply with the latest version of the following codes referenced standards:
      a. NFPA -13 – 2016 Installation of Sprinklers
      b. NFPA 14 – 2016 Installation of Standpipes And Hose Systems
      c. NFPA 20 – 2016 Installation of Stationary Pumps For Fire Protection
      d. NFPA 70 – 2017 National Electrical Code
      e. NFPA 72 – 2016 National Fire Alarm and Signaling Code
      f. NFPA 101 – 2018 Life Safety Code
      g. NFPA 110 – 2016 Emergency and Standby Power Systems
      h. Others as Identified

F. Materials and equipment installations shall comply with standards of:
   1. National Fire Protection Agency (NFPA).
   2. Local Utilities.
   3. Owner's Insurance Underwriters.
   4. Applicable Government Agencies and Departments.
   5. Underwriters Laboratory (UL).
   6. Federal and State Occupational Safety and Health Act (OSHA).
   7. Local Municipality.
   8. Local Fire Department.
   9. American Gas Association (AGA).
   10. ANSI - American National Standards Institute.
   11. ASTM Regulations and Standards for pipe, fittings, pressure vessels, testing and insulation.
   12. Conformance with the applicable codes, rules and regulations of the State of New York, NYCRR, Code Rule 4 and Code Rule 14, pertaining to boilers, gas and oil burners, controls and protective devices.
   13. AWWA American Water Works Association.
   14. Electrically powered equipment shall comply with the National Electric Code (NEC) and shall be UL listed for the intended usage.

G. Manufacturer qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

H. Approved Manufacturers:
   1. A listed approved manufacturer does not relieve or relax any specification requirements.
   2. Manufactures listed in the specifications and/or under addendum still must fully comply with the technical description as described in the project documents.

3. Inferior manufacturer's standard offerings of products will not be accepted in lieu of the specified product.
4. The Architect/Engineer shall make the final judgment in determining if a product meets the full intent of the specifications.

1.11 CONNECTIONS

A. Furnish and install utilities serving equipment which is to be furnished by others in accordance with the sizes and locations shown on the drawings complete with final connections including provisions for shut-off and adapters as required.

B. Furnish and install required conduit and fittings as noted or specified.

C. Provide disconnects at each unit.

1.12 STRUCTURAL SUPPORTS

A. Furnish and install brackets and/or supports for the electronic safety and security installations in excess of building structure as shown on drawings. Where detail is not shown, submit shop drawings of intended construction for approval.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Deliver conduits 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.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

D. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.14 COORDINATION

A. Layout of equipment, conduits, etc. is diagrammatic. Check project drawings prior to making installations for interferences with other trades. Should the contractor find such interferences, he shall be responsible for coordinating his work with the other responsible trades. Owner reserves the right to make reasonable changes prior to "roughing-in" without added expense. Dimensions shown are subject to verification of exact site conditions.

B. Refer to reflected ceiling plans, structural drawings and architectural drawings and coordinate electronic safety and security installations with ceiling patterns, lighting layouts, building structural members, etc. Coordinate the electronic safety and security installations with the work of others engaged in the installation to preclude the possibility of interference with electronic safety and security installations shown on the drawings.

C. Arrange for spaces, chases, slots, and openings in building structure during progress of construction, to allow for electronic safety and security installations.

D. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

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

1.15 PROJECT CONDITIONS

A. Contract Drawings are in part diagrammatic, intended to convey to the Contractor for the Electronic safety and security Work, the scope of work and indicate general arrangement of equipment and outlets. Follow these drawings in laying out the work. Verify spaces in which the work will be installed.

B. Verify location of existing utilities before proceeding with the work.

C. Proposed conduit routing to match existing materials being connected into unless noted otherwise.

D. Verify scope of work: Contractor shall visit the job site prior to submitting a bid to ascertain existing field conditions and to determine the scope of the work, and to become familiar with the existing conditions that will affect his work and, therefore, the bid. Additional cost resulting from the contractor’s failure to verify the scope of the work shall be the contractor’s responsibility and shall be paid by the contractor.

E. Erect and maintain temporary partitions to prevent spread of dust, odors, and noise to permit continued owner occupancy throughout the building.

F. Work areas are to be kept free of debris at all times and are to be left broom clean at the end of each working day.

G. Adjacent areas are to be protected from dust and debris.

H. Do not close or obstruct egress width to any building or site exit.

I. Contractor shall obtain and pay for required permits from authorities.

J. Conform to applicable code for the work described within the construction documents. Base bid amount shall include additional work required by the authorities having jurisdiction pertaining to the completion of this project.

K. Contractors shall follow owner’s safety requirements during construction.

L. Conform to owner’s safety procedures if hazardous or contaminated materials are discovered.

M. The owner shall direct the contractor where to store salvaged items, equipment and materials removed from the work area.

N. The owner shall direct the contractor where construction materials, furniture and equipment to be installed shall be staged and stockpiled during construction.

O. The work specified herein and indicated on drawings shall be completed, tested and made ready for operation prior to turn over to the owner. Unless specifically indicated, materials and equipment shall be new and first class quality.

1.16 SYSTEMS

A. The contractor shall be responsible to provide complete and operable systems, including operational properties to the extent necessary to link multiple components of a system together and to interface with other systems.

1.17 BASIS OF DESIGN EQUIPMENT

A. Drawings equipment schedules. Add the following general note
   1. Manufacturer and Model number of equipment included in schedule is the basis of design for project.
   2. Adjustment shall be made by the contractor for equipment other than the bases of design to comply the installed equipment manufacturer's requirements.

B. Project Manual
   1. Manufacturers
      a. Manufacturer and Model number of equipment included in specifications is the basis of design for project.
      b. Adjustment shall be made by the contractor for equipment other than the bases of design to comply the installed equipment manufacturer's requirements.

1.18 SALVAGED ITEMS

A. Remove all unused existing equipment where accessible and offer all salvage material to the owner.

B. Owner shall have first right of refusal of all salvageable materials removed from the building.

C. Materials not claimed by the owner shall become the property of the contractor.

D. The contractor shall dispose of all material not retained by the owner in a lawful and legal manner away from the site

E. Items salvaged shall be moved and stored in a location as directed by the owner.

F. The owner shall direct the contractor where to store salvaged items, equipment and materials removed from the work area.

G. At the start of the project, the Owner and contractor shall survey the building and identify all items to be salvaged and turn over to the owner

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials and equipment shall be in strict accordance with the parameters hereinafter specified and as shown on the drawings.

B. Materials and equipment furnished/provided shall be new unless noted otherwise.

2.2 ACCESSORIES

A. It is the intent of this specification that systems and equipment shall be complete with all accessories required to insure a complete system.

2.3 ELECTRICAL CONNECTIONS

A. Electrical components provided shall be in compliances and sized in accordance with the National Electrical Code NFPA 70.

B. Electronic safety and security equipment shall be UL listed.

2.4 MANUFACTURERS

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

1. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
2. Basis of Design: Subject to compliance with requirements, provide products by the manufacturers specified.

PART 3 - EXECUTION

3.1 DEMOLITION

A. Refer to specification Sections for "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove systems, equipment, and components indicated to be removed.

1. Conduit to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining conduit with same or compatible piping material.
2. Conduit to Be Abandoned in Place: Drain piping and cap or plug conduit with same or compatible piping material.

3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. The layout of conduit, equipment etc. is diagrammatic in nature. Not all components are shown on the drawings.

D. Contractor shall notify the owner in advance of any shutdown necessary of the existing systems. Minimum notification time shall be 72 hours.

E. Do not disable or disrupt building systems without 3 days prior written notice to owner.

F. Provide temporary services to maintain existing systems in service during construction.

G. Abandoned and inactive components shall be removed back to their active main or area and terminated. Including but not limited to the following conduit, raceways, or other system components shall be removed.

3.2 CUTTING AND PATCHING

A. The contractor shall be responsible for cutting and patching as described herein or as indicated on the drawings. The contractor shall be responsible for coordinating his cutting and patching requirements with the other trades.

B. Connection of new services to existing shall be in a neat and approved manner with disturbed services restored to original condition.

C. Do cutting and patching work as noted and as necessary for the installation of the electronic safety and security work.

D. Cut, channel, chase, and drill ceilings, and other surfaces necessary for electronic safety and security installations. Perform cutting by skilled mechanics of trade involved.

E. Repair cut surfaces to match adjacent surfaces.

F. The contractor is responsible for cutting and patching of existing work to facilitate and to conceal the work described within these documents. Surfaces to be patched shall be finished to match the existing surface. Owner has final say as to the acceptability of the finished patched work.

G. Core drill openings in concrete floors necessary for systems.

3.3 INSTALLATION

A. Unless otherwise noted or specified, materials and equipment shall be installed in strict accordance with the manufacturer’s instructions and recommendations.

B. Do not scale Drawings.

C. The location of new conduit and raceways are approximate. The exact location of conduit and equipment shall be determined in the field to:
   1. Provide manufacturer's recommended clearances.
   2. Avoid interference with existing conditions.
   3. Avoid interference with new work of other trades.

D. Provide additional fittings as required to effect required changes in direction and elevation.

E. Provide additional offsets and fittings as required to accommodate obstructions that are to remain.

F. Do not cut any structural building member without permission of the Architect/Engineer.

G. Provide interlocking controls for air handlers with the building fire alarm system. Upon activation of the building fire alarm system, the fans within the air handlers shall be shut down. Coordinate installation with the manufacture of the building fire alarm system.

H. The actual relative locations of conduit, receptacles, equipment, etc. shall be adjusted during construction according to final placement of equipment.

I. The contractor shall provide required offset, transitions, fittings, and components etc. as required to complete the installation of the systems in order to conform to the building structure and existing building systems. This shall include but not be limited to piping systems, duct systems, etc.

J. Systems serving other areas of owner's facilities shall remain active and fully functional throughout the duration of the project for Owner occupied areas. System shutdowns shall be coordinated with owner's field representative as required to accomplish system tie in, system extension and/or system removal work.

K. Work on existing systems that are to remain active during construction shall be coordinated with owner's field representative.

L. Contractor is responsible for verification of all dimensions.

M. The layout of conduit, boxes, receptacles, equipment etc. is diagrammatic in nature. Provide required offsets to accommodate obstructions and final system placement.

N. Unless noted otherwise, system components shall not be exposed. Conduits and raceways shall be concealed within the ceilings and wall structures.

O. The drawings do not show all off sets or fittings required for installation. Schematic diagrams convey the configuration and system components, but not all of the fittings required for the final installation are shown.

3.4 PROTECTION

A. All materials, equipment and accessories shall be suitably protected and covered during construction.

B. Damage responsibility: The contractor shall be responsible for any loss or damage caused by him or his workmen to the facility, building surfaces or equipment during the course of construction, and shall be fully responsible for repairing or replacing as required to insure restoration to original condition.

C. Damaged items: Where items scheduled for reuse are found to be in damaged condition, the contractor shall call the attention of the owner to such items and receive further instructions prior to removal. Items damaged during removal shall be repaired or replaced by the contractor at no additional cost to the owner.

D. Repair damages: Promptly repair damage to adjacent facilities by demolition operations at no cost to the owner.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install 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.

3.6 PAINTING AND FINISHING

A. Painting of systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 CEILING SYSTEM NOTES

A. Plaster frames shall be provided for equipment installed in plaster or gypsum board ceiling.

B. Lay-in frames shall be compatible with the ceiling grid system. Note where standard and micro-grid ceiling systems are to be installed throughout the project area. Coordinate equipment frames accordingly.

3.8 FIRE PROTECTION

A. Fire rated assemblies: Provide fire retardant NRTL approved sealant on raceway penetrations of fire rated ceilings, partitions, walls, and structural slabs. It shall be the responsibility of the Contractor to verify locations of such fire rated partitions, walls and structural slabs prior to submitting bid.

B. Fire rated assemblies: Fire rated assemblies to be penetrated shall be installed with applicable through-penetration fire-stop system determined by U.L. classification.

C. Fire alarm system modification shall be coordinated with central security before making any alterations.

3.9 ACCESS DOORS – FINISHED SURFACES

A. Provide wall, ceiling or floor access doors at locations where equipment, data and cable raceways, j-boxes, and other components needing access that are located within concealed spaces. Typical for walls, floor and ceilings.

B. Provide wall, ceiling or floor access doors where equipment and raceways are not exposed. Doors shall be flushed mounted with key lock, with full piano hinge sized to adequately access components and raceways.

C. Access doors shall be flushed mounted with key lock to Owners keying system, with full piano hinge sized to adequately access components and not smaller than 12”x12”.

D. Access doors shall be rated for the assembly they are to be installed in.

E. Doors shall be polished stainless steel finished unless noted otherwise

F. Refer to division 8

3.10 ADA WALL MOUNTING HEIGHT

A. Wall mounted components that require adjustment or manual operation shall be mounted so the top of the unit is 40” above the finish floor or below.

B. Wall mounted sensors that do not require adjustment or manual operations shall be mounted so the top of the unit is 54” above the finish floor or below.

C. Wall mounted receptacles shall be mounted a minimum of 18” above finish floor to the center of the box.

3.11 INSPECTIONS

A. The Contractor shall have:
   1. Required local or municipal inspection processed and present Owner with certificate indicating approval of such governing bodies.

END OF SECTION 280500

SECTION 281500 – ACCESS CONTROL

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. Card readers
   2. Request to exit sensors
   3. Device mounting brackets
   4. System wiring
   5. Terminations

1.3 RELATED REQUIREMENTS

A. Section 087100 “Door Hardware”

B. Section 260519 “Low-Voltage Electrical Power Conductors and Cables”

C. Section 260529 “Hanger and Supports for Electrical Systems”

D. Section 260533 “Identification for Electrical Systems”

E. Section 260533 “Raceway and Boxes for Electrical Systems”

1.4 REFERENCE STANDARDS

A. NFPA 70 “National Electric Code; National Fire Protection Association”

B. NFPA 72 “National Fire Alarm and Signaling Code; National Fire Protection Association”

C. NFPA 80 “Standard for Fire Door and Other Opening Protectives; National Fire Protection Association”

D. NFPA 101 “Life Safety Code; National Fire Protection Association”

E. IBC 2021; “International Building Code”

F. UL 294; “Standard for Access Control System Units”

1.5 SCOPE

A. General
1. Provide all labor, materials equipment and services to perform all operations required for the complete installations and related work as shown in all documents.
2. Provide all equipment and accessories to integrate with existing Campus Access Control system as described herein and shown in the drawings.
3. Model numbers and designations, which appear herein, indicate basis of design, quality and type of material as well as operating characteristics.
4. The products shall be built modular in construction for ease of expansion and service. Functions shall be on replaceable panels or modules to accommodate functional changes when required.

B. Contractor
1. Furnish and install pathways at access-controlled doors.
2. Furnish and install wiring at access-controlled doors.
3. Furnish and install pathways from access-controlled doors to closet/room containing card access control panel.
4. Furnish and install wiring from access-controlled doors to closet/room containing card access control panel.
5. Furnish and install card readers, request to exit sensors and power supplies at access-controlled doors. Location of power supplies shall be determined in field.
6. Furnish and install wiring to interconnect electrically actuated door hardware furnished under specification section 087100 “Door Hardware”.
7. Furnish and install wiring to interconnect electrically actuated ADA door operator and pushbuttons furnished under specification section 087100 “Door Hardware”.

C. University
1. Furnish and install card access control panel.
2. Furnish and install associated control panel power supplies.
3. Terminate wiring furnished and installed by Contractor at access control panels.
4. Furnish and install card access software.
5. Program card access control panel.

1.6 PRE-INSTALLATION MEETING

A. Agenda:
1. Coordination of door hardware as identified in specification section 087100 “Door Hardware” with access control devices identified in this specification.
2. Coordination shall include but not limited to:
   a. Hinges
   b. Panic hardware
   c. Lockset
   d. ADA hardware power supply

B. Attendees:
1. University physical security
2. Electrical contractor
3. Electrical contractor access control sub-contractor (if applicable)
4. Access control device manufacturer’s representative.

5. Door hardware manufacturer's representative.
6. Project architect
7. Project electrical engineer.

C. Location:
1. Electrical contractor shall coordinate with attendees listed above and schedule the meeting.
2. Meeting shall take place at a location of the University's choosing.
3. Meeting shall take place prior to the submittal phase of both specifications 087100 & 281500.

1.7 SYSTEM OPERATION

A. Access Control
1. The University access control system utilizes a Genetec headend. All card readers, request to exit sensors and associated components shall be compatible with this system.
2. The University has a variety of spaces with different users, requiring each case to be reviewed for specific functions and user's needs. However, a typical system includes:
   a. Access-controlled doors with the following items:
      1) Card reader
      2) Electronic locking device
      3) Request to exit sensor with audible capabilities
      4) Door contacts
      5) Access control panel with enclosure, cards, and power supplies.
   b. In additional to items above the following may be included:
      1) Interface to ADA door power operator and associated push buttons.
3. Door device wiring shall gather in a junction box and run to the nearest access control panel location.
4. Access control is utilized on interior as well as exterior doors.
5. All access control panels are connected to the Genetec head via the University IT network.

1.8 CAMPUS STANDARDS

A. All wiring shall be concealed in conduit or cable tray.

B. The access control shall be powered via the stand-by power system.

C. All electric locks shall be equipped for *fail secure*, not *fail safe*.

D. Residence hall buildings:
1. Secured 24hr a day.
2. Outer vestibule doors on residence halls are un-secured.
3. Interior vestibule doors are secured.

E. State buildings:
1. Outer vestibule doors secured.
2. Inner vestibule doors un-secured

F. Wiring shall be installed in a fashion which complies with local code and must not impact or interfere with other trades' equipment and visually appealing in exposed areas.

G. Wiring shall not be installed in the same raceway as line voltage power. This includes a separate pathway to ADA door operator. Pathways may be shared with other telecom equipment by the amount of wire needed for door access equipment must be considered when determining size and type of raceway.

H. Wiring shall be installed to the location of the card access control panel with enough wiring to reach the hung plywood that the control panel will be installed on plus an additional 10' for landing.

I. Wiring shall be installed at the access-controlled door location with enough wiring to reach the farthest piece of hardware plus an additional 6" service loop.

J. Wiring shall be clearly labeled on the closet end with architectural drawing door number.

K. Wiring that needs to spliced or accessed at a later date a minimum 24" x 24" access panel shall be furnished and installed at the location. Access panel shall match the fire rating of the wall or ceiling installed in.

1.9 SUBMITTALS

A. Shop Drawings: Provide device wiring diagrams showing each connection required.

B. Product Data: Provide electrical characteristics and connection requirements.

C. Pre-installation meeting documentation: Provide documentation confirming access control devices submitted under this specification will integrate with door hardware being provide under specification section 087100 "Door Hardware".

D. Manufacturer's Installation Instructions: Indicate applications, conditions and limitations of use stipulated by product testing agency. Including instructions for storage, handling, protection, examination, preparation, installation and starting of product.

E. Operating and Maintenance Instructions: Submit manufacturer's operation and maintenance instructions.

1.10 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70, 72, 80, 101, UL 294 & IBC

B. Products:
   1. Utilize manufacturers regularly engaged in the manufacturing of access control devices required for this project's application, whose products have been in satisfactory use in similar service for a minimum of 5 years.
   2. Furnish Products listed and classified by Underwriters Laboratories Inc. as suitable for purpose specified and indicated.
   3. Device shall be new and the standard products of the manufacturer, the re-use of existing devices shall not be allowed.

1.11 DELIVERY, STORAGE AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.

B. Storage: Store materials indoors, in a clean, dry area in accordance with manufacturer's instructions.

C. Handling: Protect materials and finishes during handling and installation to prevent damage.

PART 2 - PRODUCTS

2.1 CARD READERS (CR)

A. General:
1. Bluetooth credential capability: 2.4 GHz
2. NFC credential capability: 13.56 MHz
3. Credential capability: 125 KHz
4. Read range: 1.6 to 4 inches
5. Color: Black bezel with silver trim baseplate.
6. Keypad (CR-3 only): 3 x 4 layout
7. Dimensions:
   a. CR-1: 3.15 in (W) x 4.78 in (L) x 0.77 in (D)
   b. CR-2: 1.78 in (W) x 4.79 in (L) x 0.85 in (D)
   c. CR-3: 3.16 in (W) x 4.79 in (L) x 0.85 in (D)
8. Product weight:
   a. Pigtail: 4.94 oz
   b. Terminal: 4.23 oz
9. Operating voltage: 12V DC
10. Current Draw:
    a. Normal standby current: 65mA
    b. Peak: 250mA
    c. Max. Avg.: 75mA
    d. Intelligent power management: 45mA
11. Device input: Tri-color LED, Buzzer, Hold @ active low
12. Device Output: Tamper relay 0-60V DC @ 100mA Max (dry contact)
13. Operating temperature: -31 deg F to +150 deg F
14. Operating humidity: 0% to 95% non-condensing.
15. Storage temperature: -40 deg F to +185 deg F
16. Environmental rating: UL 294 Outdoor and Indoor rated, IP65
17. Transmit frequency: 125 kHz, 13.56 MHz and 2.4 GHz
18. Communications:
    a. Wiegand
    b. Clock-Data
    c. RS-485 Half Duplex
19. Panel connections: 18 in pigtail or Terminal strip
20. Certifications: UL 294 and FCC
21. Housing materials: Polycarbonate – UL 94 V10

B. Basis of Design

1. Card Reader Type 1, Standard (CR-1) - HID Signo Reader, 40NKS-00-00ETCJ

2. Card Reader Type 2, Mullion (CR-2) - HID Signo Reader, 20NKS-00-00ETCJ

3. Card Reader Type 3, Keypad (CR-3) - HID Signo Reader, 40-KNKS-00-00ETCJ

2.2 REQUEST TO EXIT SENSOR (REX)

A. General:

1. Door monitor with adjustable sounder alert up to 85 dB.
2. Sequential logic input.
3. Keycard input allowing sensor to be controlled from external source.
4. Internal vertical point-ability
5. Wrap-around coverage pattern with precise pattern control
6. Up to 64 second adjustable latch time.
7. Certifications: and approvals: UL 294
8. Operating temperatures: -20 deg F to +120 deg F
9. Radio frequency: No Alarm or setup on critical frequencies in the range from 26 MHz to 1000 MHz at 50 V/m
10. Complies with environmental Class II (EN50130-5)
11. Dimensions: 1.80 in x 6.75 in x 1.75 in
12. Material: High impact ABS plastic enclosure
13. Power loss default: Programmable fail-safe or fail-secure modes
14. Timer: Programmable reset accumulative or non-reset counting mode
15. Current draw: 8 mA nominal standby current, 39 mA a 12 VDC in alarm
16. Voltage: 12 VAC or VDC to 30 VAC or VDC
17. Alarm output: Two form C relay contacts each rated 1 A at 30 VAC or VDC for resistive loads
18. Coverage: 8 ft x 10 ft with a detector mounting height of 7.5 ft.
19. Trim plate: Mounting sensor over a standard single gang box or tile ring

B. Basis of Design: Bosch, DS-160 with TP160 trim plate.

2.3 DEVICE MOUNTING BRACKETS

A. General:

1. No sharp edges with plastic design
2. No installation tools required to secure bracket in the drywall opening
3. Serrated interlocking system secures tightly
4. Template points on brackets help eliminate multiple measurement markings during installation
5. Recessed design helps assure flush mount of device
6. Eliminates the need for electrical boxes on low voltage class 2 applications.
7. Material: Acrylonitrile butadiene styrene
8. Finish: Plain
9. Gang: Single
10. Drywall thickness: ¼ in to 1 ¼ in

B. Basis of Design: nVent/Caddy, MP1P

2.4 SYSTEM CABLING

A. Control cable type 1 (CC-1)
1. Description: A cable composed of (4) individually jacketed cables.
2. Individual cable 1:
a. Conductor:
1) Size: 18 AWG
2) Strands: 7
3) Class: B
4) Material: Annealed bare copper
5) Number of conductors: 4
b. Insulation:
1) Material: Plenum rated polyvinylchloride
2) Wall thickness: 0.007 in
3) Color code: Black, red, white and green
c. Assembly:
1) Nominal lay length: 2.50 LHL (4.80 Tw/Ft)
2) Shield/drain wire: N/A
d. Jacket:
1) Material: Plenum rated polyvinylchloride
2) Wall thickness: 0.015 in
3) Diameter: 0.190 in
4) Color: Natural/Purple
5) Weight: 32 lbs./Mft
e. Markings:
1) Type: Cable shall be permanently identified via surface inkjet print
2) Legend: ***LOCK POWER/PIR***DOOR LOCATION A B C D E F / 0 1 2 3 4 5 6 7 8 9 10 11 12 E171197 18AWG 4C (UL) CMP C(UL) OR (UL) CL3P 75’C FT-6 “ROHS II” MADE IN USA
3) Footage markers: Yes
3. Individual cable 2:
a. Conductor:
1) Size: 22 AWG
2) Strands: 7
3) Class: B
4) Material: Annealed bare copper
5) Number of conductors: 3 pairs
b. Insulation:
1) Material: Plenum rated polyvinylchloride
2) Wall thickness: 0.007 in
3) Color code: Black x red, green x white, orange x brown
c. Assembly:
1) Pair lay length: 2.00 LHL (6.00 Tw/Ft)
2) Cable lay length: 2.50 LHL (4.80 Tw/Ft)
3) Cable shield: Aluminum/mylar – 100% coverage
4) Cable drain wire: 24 AWG, 7 strand, tinned copper
d. Jacket:
1) Ripcord: Yes
2) Material: Plenum rated polyvinylchloride
3) Wall thickness: 0.015 in
4) Diameter: 0.183 in

5) Color: Natural/Yellow
6) Weight: 25 lbs./Mft

e. Markings:
1) Type: Cable shall be permanently identified via surface inkjet print
2) Legend: ***CARD READER***DOOR LOCATION A B C D E F / 0 1 2 3 4 5 6 7 8 9 10 11 12 E171197 22AWG 3PR (UL) CMP C(UL)US OR (UL) CL3P 75'C FT-6 "ROHS II" MADE IN USA
3) Footage markers: No

4. Individual cable 3:
a. Conductor:
1) Size: 22 AWG
2) Strands: 7
3) Class: B
4) Material: Annealed bare copper
5) Number of conductors: 2

b. Insulation:
1) Material: Plenum rated polyvinylchloride
2) Wall thickness: 0.007 in
3) Color code: Black, red

c. Assembly:
1) Nominal lay length: 3.00 LHL (4.00 Tw/Ft)
2) Shield/drain wire: N/A

d. Jacket:
1) Material: Plenum rated polyvinylchloride
2) Wall thickness: 0.015 in
3) Diameter: 0.115 in
4) Color: Natural/Green
5) Ripcord: Yes
6) Weight: 9 lbs./Mft

e. Markings:
1) Type: Cable shall be permanently identified via surface inkjet print
2) Legend: ***DOOR CONTACT***DOOR LOCATION A B C D E F / 0 1 2 3 4 5 6 7 8 9 10 11 12 E171197 22AWG 2C (UL) CMP C(UL)US OR (UL) CL3P 75'C FT-6 "ROHS II" MADE IN USA
3) Footage markers: No

5. Individual cable 4:
a. Conductor:
1) Size: 22 AWG
2) Strands: 7
3) Class: B
4) Material: Annealed bare copper
5) Number of conductors: 4

b. Insulation:
1) Material: Plenum rated polyvinylchloride
2) Wall thickness: 0.007 in
3) Color code: Black, red, white, green

c. Assembly:
1) Nominal lay length: 1.75 LHL (6.86 Tw/Ft)
2) Shield/drain wire: N/A

d. Jacket:
1) Material: Plenum rated polyvinylchloride

2) Wall thickness: 0.015 in
3) Diameter: 0.132 in
4) Color: Natural/Red
5) Ripcord: Yes
6) Weight: 15 lbs./Mft

e. Markings:
1) Type: Cable shall be permanently identified via surface inkjet print
2) Legend: ***REX/SPARE***DOOR LOCATION A B C D E F / 0 1 2 3 4 5 6 7 8 9 10 11 12 E171197 22AWG 4C (UL) CMP C(UL)US OR (UL) CL3P 75'C FT-6 "ROHS II" MADE IN USA
3) Footage markers: No

6. Overall cable:
a. Assembly:
1) Nominal lay length: 5.75 LHL (2.09 Tw/Ft)
2) Shield: N/A
3) Drain wire: N/A

b. Jacket:
1) Material: Plenum rated polyvinylchloride
2) Wall thickness: 0.015 in
3) Diameter: 0.412 in
4) Color: Yellow
5) Ripcord: Yes
6) Weight: 104 lbs./Mft

c. Markings:
1) Type: Cable shall be permanently identified via surface inkjet print
2) Legend: LAKE CABLE PLENUM ACCESS CONTROL CABLE A B C D E F / 0 1 2 3 4 5 6 7 8 9 10 11 12 E171202 18AWG 4C + 22AWG 3PR SHLD + 22AWG 4C + 22AWG 2C (UL) CMP C(UL)US OR (UL) CL3P 75'C FT-6 "ROHS II" MADE IN USA
3) Footage markers: Yes

d. Standards:
1) Maximum operating voltage 300V RMS

B. Basis of design: Lake Cable, S16C4ECMP-04

C. Control cable type 2 (CC-2)
1. Conductor:
a. Size: 18AWG
b. Strands: 7x26
c. Material: Bare copper
d. Number of conductors: 2

2. Insulation:
a. Material: Low smoke polyvinyl chloride
b. Wall thickness: 0.009 in
c. Color code: Black, red

3. Outer shield:
a. Material: Aluminum foil-polyester tape with shorting fold
b. Coverage: 100%
c. Drain wire: 24AWG, 7x32, tinned copper

4. Outer jacket:
a. Material: Low smoke polyvinyl chloride

b. Wall thickness: 0.015 in
c. Ripcord: Yes

5. Overall cable:
a. Nominal diameter: 0.162 in
b. Operating temperature: 0 deg C to +75 deg C
c. UL temperature rating: 75 deg C
d. Bulk cable weight: 21.400 lbs./1000 ft
e. Max recommended pulling tension: 57 lbs.
f. Min. bend radius (install) minor axis: 1.625 in
g. NEC/UL specification: CMP
h. NEC article: 800
i. UL flame test: NFPA 262
j. Plenum rated: Yes
k. Nominal inductance: .15uH/ft
l. Nominal capacitance conductor to conductor: 70 pF/ft
m. Nominal capacitance conductor to other conductor & shield: 126 pF/ft
n. Nominal conductor DC resistance: 6.4 Ohm/1000ft DCR @ 20 deg C
o. Nominal outer shield DC resistance: 15.900 Ohm/1000ft DCR @ 20 deg C
p. Max. operating voltage – UL: 300V RMS
q. Max. recommended current: 5 amps per conductor @ 25 deg C.

D. Basis of Design: Belden, B6300FE-U1000

E. Control cable type 3 (CC-3)
1. Conductor:
a. Size: 22AWG
b. Strands: 7x30
c. Material: Bare copper
d. Number of conductors: 2
2. Insulation:
a. Material: Low smoke polyvinyl chloride
b. Wall thickness: 0.009 in
c. Color code: Black, red
3. Outer shield:
a. Material: Aluminum foil-polyester tape with shorting fold
b. Coverage: 100%
c. Drain wire: 24AWG, 7x32, tinned copper
4. Outer jacket:
a. Material: Low smoke polyvinyl chloride
b. Wall thickness: 0.015 in
c. Ripcord: Yes
5. Overall cable
a. Nominal diameter: 0.128 in
b. Lay length and direction: 2.5 in, 4.8 Tw/Ft
c. Operating temperature: 0 deg C to +75 deg C
d. UL temperature rating: 75 deg C
e. Bulk cable weight: 11.300 lbs./1000 ft
f. Max recommended pulling tension: 24 lbs.
g. Min. bend radius (install) minor axis: 1.300 in
h. NEC/UL specification: CMP
i. NEC article: 800

j. UL flame test: NFPA 262
k. Plenum rated: Yes
l. Nominal inductance: .17uH/ft
m. Nominal capacitance conductor to conductor: 55 pF/ft
n. Nominal capacitance conductor to other conductor & shield: 99 pF/ft
o. Nominal conductor DC resistance: 16.4 Ohm/1000ft DCR @ 20 deg C
p. Nominal outer shield DC resistance: 15.3 Ohm/1000ft DCR @ 20 deg C
q. Max. operating voltage – UL: 300V RMS
r. Max. recommended current: 2.8 amps per conductor @ 25 deg C.

F. Basis of Design: Belden, B6500FE-877U1000

G. Control cable type 4 (CC-4)
1. Conductor:
a. Size: 22AWG
b. Strands: 7
c. Material: Bare copper
d. Number of conductors: 6
2. Insulation:
a. Material: Low smoke polyvinyl chloride
b. Wall thickness: 0.009 in
c. Color code: Black, red, white, green, brown and blue
3. Outer shield:
a. Material: Aluminum foil-polyester tape with shorting fold
b. Coverage: 100%
c. Drain wire: 24AWG, 7x32, tinned copper
4. Outer jacket:
a. Material: Low smoke polyvinyl chloride
b. Wall thickness: 0.015 in
c. Ripcord: Yes
5. Overall cable
a. Nominal diameter: 0.175 in
b. Operating temperature: 0 deg C to +75 deg C
c. Bulk cable weight: 24.400 lbs./1000 ft
d. Max recommended pulling tension: 60.100 lbs.
e. Min. bend radius (install) minor axis: 1.800 in
f. NEC/UL specification: CMP
g. UL flame test: NFPA 262
h. Plenum rated: Yes
i. Nominal capacitance conductor to conductor: 33 pF/ft
j. Nominal capacitance conductor to other conductor & shield: 59 pF/ft
k. Nominal conductor DC resistance: 16.2 Ohm/1000ft DCR @ 20 deg C
l. Nominal outer shield DC resistance: 15.3 Ohm/1000ft DCR @ 20 deg C
m. Max. operating voltage – UL: 300V RMS
n. Max. recommended current: 2 amps per conductor @ 25 deg C.

H. Basis of Design: Belden, B6504FE-877U1000

2.5 TERMINATIONS

A. General:
1. Insulation type: Nylon fully insulated
2. Terminal material: ETP copper
3. Temperature rating: -40 to 221 deg F
4. Approval:
a. Female: UL 486C
b. Male: UL 310
5. Type: Funnel entry
6. Tab size: 0.25 in (W) x 0.032 in (T)
7. Conductor size:
a. Minimum: 22 AWG
b. Maximum: 18 AWG
8. Color: Red
9. Barrel style: butted
10. Voltage:
a. 600V: Building wire
b. 1000V: Signs and Fixtures

B. Basis of design:
1. Female: 3M, Scothlok, MNU18-250DFIX
2. Male: 3M, Scothlok, MNU18-250DMIX

PART 3 - EXECUTION

3.1 PREPERATION

A. Cabling installed by door type:
1. Standard installation:
a. Description: Reader, REX and powered door hardware
b. Cabling required:
1) CC-1, Qty. of (1)
2. Standard installation + ADA door operator
a. Cabling required:
1) CC-1, Qty. of (1)
2) CC-4, Qty. of (1)
3. Emergency egress only
a. Description: Alarm will sound when opened, no electric hardware
b. Cabling required:
1) CC-4, Qty. of (1)
4. Egress only
a. Description: Alarm will sound on forced open or held open, no electric hardware
b. Cabling required:
1) CC-4, Qty. of (1)
2) CC-3, Qty. of (1)
5. Monitored only
a. Description: Contact only
b. Cabling required:

1) CC-3, Qty. of (1)

B. Hinge preparation
1. Provide ½" conduit from cable tray, above ceiling or from REX box through the frame to the center hinge or second hinge from the floor with a pull string. Doors with 2 leaves need this prep for both.
2. Doorways using contacted hinges with power (CECS) shall have a pair of ¾" deburred holes in the frame that matches with the contact and power cables.
3. Doorways using only a contact hinge (CS) or electric hinge (CE) shall have (1) ¾" deburred hole in the frame that matches up with the power wires or contact.
4. The cavity behind where a contact will be located needs to be large enough to house the contact and wiring that come from the back of the contact without stripping or pinching the wiring.

C. Request to exit (REX) preparation
1. A REX shall have a ½" conduit (3/4" conduit if the box is being used as the split point of the access control cable) from the cable tray or from above ceiling to a horizontal single gang box centered above the door where the sensor won't be obstructed. Pull string shall be added to the conduit. An acceptable alternative when there are drop ceilings is to mount a single gang low voltage mounting bracket into an empty ceiling tile towards the center of the door perpendicular with the opening.
2. Regardless of installation method chosen, REX sensor shall have an unobstructed view of the floor in front the door being served.

D. Card read (CR) preparation
1. Card readers shall have a ½" conduit from cable tray, above ceiling or from the REX box to a vertical single gang box in the wall on the latch side of the door at 44" AFF. If prepping for a store front door, the conduit from the cable tray, above ceiling or from the REX box shall be brought into the closest stud that does not contain the strike plate on the latch side to a ½" hole a 44" AFF (this may vary depending on the opening). Pull string shall be included with the conduit. If an ADA operator is present at the door, the reader box shall be installed in a location available to the individual(s) requiring ADA access that does not obstruct door operation.

E. ADA operator preparation
1. ADA operator location shall not obstruct the view of the REX sensor.
2. Provide ½" conduit from cable tray, above ceiling or from the REX box and connect to the ADA operator enclosure.
3. If being installed on the unsecured side, the door shall have a vertical single gang box next to the reader box (not obstructing the door) with a connection to the reader box or a separate ½" conduit back to the cable tray, above ceiling or the REX box for the outside push button. There should be a separate vertically hung single gang box on the secure side of the door with appropriate conduit for the inside push button. The box shall be installed in a location available to the individual(s) requiring ADA access that does not obstruct door operation.
4. Provide 4" sq backboxes for ADA operator push buttons.

F. ADA hardware power supply preparation
1. Provide a 120V, 20A branch circuit to location within 200' of ADA door.
2. Circuit with (2) #12 AWG, (1) #12 AWG equipment ground in minimum ½" conduit.
3. Circuit shall be supplied by a stand-by power panelboard.

4. Space dedicated for ADA power supply shall have the following:
   a. Ample Working clearances allowing technicians access for future troubleshooting.
   b. Out of public view.
   c. Minimum of 1 ½’ x 1 ½’ mounting area for power supply.
   d. Power supply door shall be able open a minimum of 90 deg.
   e. Minimum 36” clear space in front of power supply.
   f. Preferred location of power supply is above a drop ceiling that is easily accessible, unobstructed and withing 200’ of the ADA door.

G. Contact preparation
1. In the event a contact is not part of the hinge (i.e., storefront or aluminum doors) a raceway with a pull sting shall be provided to the top of the frame 6” away from the strike side of the door. The hole size shall be dependent on the contact being installed.

3.2 INSTALLATION

A. Installation methods describe below are based on specified access control devices and wiring identified in this specification as well as hardware identified in specification section 087100 “Door Hardware”. If alternate devices, wiring and or door hardware are submitted and approved, the installation shall be in full compliance with submitted manufacturers written instructions. In lieu of methods described below, contractor shall furnish proposed installation methods and submit to University Physical Security for approval prior to beginning installation.

B. Card reader (CR)
1. The yellow striped cable inside CC-1 shall be pulled down to the card reader single gang box plus an additional 8” for a service loop from where the cable splits. On a store front style door, the cable will be pulled to the ½” hole.
2. 4” of yellow insulation shall be peeled back to expose the 6 internal wires plus the ground wire. Use electrical tape where the cut was made to cover the insulation.
3. Attach the back plate of the reader the single gang box or stud using standard #6/32 machine screws. Then pull the yellow reader cable through the opening.
4. The cable that comes from the reader shall have all the ends minus the ones being used for install cut off and loosely taped back. Care shall be taken that the colors of the wire do not have another color mixed on the same wire as these are for a different function.
5. The wires shall be spliced together by function. The “normal” color to color wires with functions are listed below. If variations are present, contact University Physical Security for correct wiring.

CARD READER WIRE CONNECTIONS		
ACCESS CONTROL CABLE (CC-1)	CARD READER PIGTAIL	FUNCTION
RED	RED	DC+
ORANGE	ORANGE	LED
BROWN	YELLOW	BZR
WHITE	WHITE	CLK D1
GREEN	GREEN	DAT D0
BLACK	BLACK	DC-
BARE/GROUND WIRE	BARE/GROUND WIRE	GROUND

C. Request to exit (REX)
1. The red stripped cable inside CC-1 + CC-2 shall be pulled to the REX horizontal single gang box or REX mounting bracket in the drop ceiling.
2. The red wire of CC-2 shall be spliced into the white wire from the purple striped strand (the power cable) that is in CC-1.
3. The outer layer of insulation on both wires shall be pulled back approximately 8" to expose (4) "REX" wires as well as the (2) 18/2 wires
4. Attach the base plate to the box using a 6-32 x ¾" screw through the right side only leaving approximately ¼" of the screw not tightened. The white and green wires from the REX strand of CC-1 shall go through the square hole farther from the door; the red and green wires from the REX stand of CC-1 along with the red wire from CC-2 shall go through the square hole closet to the door.
5. Attach the REX base plate by putting the right screw hole over the screw that has ¼" exposed. Pull the wires through the gaps on the left side of the base plate either away or closer to the door noted in previous step. Tighten the original screw and add the second screw in to the left side of the base plate. Make sure the wires have room to move in and out of the base plate.
6. Loosen the black screw and attached the REX sensor to the base plate so that the sensor is to the right and the terminal block is on the left.

REQUEST TO EXIT SENSOR WIRE CONNECTIONS	
ACCESS CONTROL CABLE	REX TERMINAL BLOCK
CC-1 (RED REX WIRE)	"+"
CC-2 (BLACK REX WIRE)	"-"
CC-2 (RED WIRE)	"R"
CC-1 (GREEN REX WIRE)	"C"
CC-1 (WHITE REX WIRE)	"NC"

REQUEST TO EXIT SENSOR DIP SWITCH POSITION	
DIP SWITCH	ON / OFF
1	ON
2	ON
3	OFF
4	OFF
5	ON
6	ON
7	ON
8	OFF
9	OFF
10	ON

7. Point the sensor straight down and tighten the black screw to hold it in place.
8. If there is glass to either side of the sensor use the provided panels to cover the sensors outermost area.

D. Hinge
1. Verify that the appropriate prep work is done for the hinge scenario that is being used for both the door and frame. This will help to keep the access control cables, hinge cables and door power cables from being damaged during installation.

2. If door is a standard setup and the hinge is CECSCB the purple striped power cable and the green contact cable from CC-1 shall be pulled to the prepped hinge. The purple cable should come out the center hinge hole and the green contact cable should come out the upper hinge hole. If the door is contact only (CS) or power only (CE) then only the wire being used shall be pulled to the center hole. Wires shall have a minimum of 6" excess for future repairs.
3. Strip back 3" of outside jacket on both wires and prep for splice. Remove the green and white wire from the power wire to where the jacket was cut.
4. On a standard hinge setup take the 18 AWG red and black wires out of the hinge tape and prep from splice on both sides of hinge. Cut off the end and the red wire that is placed across from the contact on the frame side and prep the white and black wires that are left for splice.
5. The wiring shall be spliced as follows:

HINGE SPLICES	
CONTROL CABLE	SPLICED TO
CC-1, red wire (power)	Hinge cable, red 18 AWG wire
CC-1, black wire (power)	Hinge cable, black 18 AWG wire
CC-1, red wire (contact)	Hinge cable, white contact wire
CC-1, black wire (contact)	Hinge cable, black contact wire

6. Put excess wire back into the frame or door carefully so as to not strip or pinch the wires and use a #3 Phillips head to screw in the hinge. Use caution to and securely tighten the hinge and not strip the screws. If any push back/resistance is felt on the hinge, the pocket for the contact may not have been hollowed out enough or a wire may have been pinched in between the hinge and door/frame. DO NOT FORCE. The wires may break too close to the hinge and be irreversible damaged if excessive force is used.
7. If the gap between the hinge leaves is larger than an 1/8", provide shimming as required to allow switch to confirm door is in the closed position

E. Door
1. Lock
   a. Based on: Best, 9k Cylindrical 24v DEU / Cylindrical lock with mortise
      1) Verify that door hardware is correct, the handle on any cylindrical lock should be DEU (door electronically unlocked). The handle on the unsecure side of the door shouldn't move until voltage is applied to it, while the handle on the secure side should freely move and pull back the latch. There should be no option to leave the door unlocked (i.e., classroom function). The inside handle and latch should move freely. The door shall not rub the frame or threshold. When the door is closed the deadlatch shall be compressed and the main latch shall be completely out into the strike. The latch and strike plate shall not rub against each other.
      2) Verify a wiring path from the lock through the door to the hinge side has been provided. Enough room on the hinge side shall be provided to accommodate the contact and an additional 6" of wire for a service loop.
      3) Verify that there is ample room for the temperature control module (generally not included with mortise) and extra wire on the chassis side. Make sure that there is a hole on the unsecured side of the door where the power wire has to slide in with the chassis to avoid pinching or stripping the wire (not applicable to mortise).

4) Install wire that comes with the temperature control module or by itself through the door leaving the plug and temperature control module on the chassis side. Connect wires and carefully reassemble the hardware back on the door. Caution shall be taken to ensure wires are not stripped or pinched. In the event wires are damaged during installation, new hardware shall be furnished and installed at the contractor's expense.
5) Provide 6" of additional cable on the hinge side of a service loop and connections to hinge. Refer to hinge installation instructions for wiring at hinge end.

2. Panic hardware
   a. Based on: Von Duprin, 99/98 series QEL
      1) Verify that panic hardware has been installed correctly. The hardware shall have a fixed handle on the unsecure side. The lock shall work in storeroom function only. The panic bar shall glide easily back and forth. The door shall shut on its own and the latch shall meet the strike and come back to its resting point without any added force. Once closed the deadlatch shall keep the latch from pushing in and there shall not be any rubbing on the strike plate when the latch is pulled back in.
      2) A drilled hole shall be provided from the hinge prep to meet with the hinge side behind the panic bar. This hole shall be large enough to run the necessary wire(s) through without pinching or stripping.
      3) The QEL has 4 wires that come from the motor. The (2) blue wires may be trimmed to 4" and any bare wire may be eliminated. The (2) brown wire shall be prepped with a male termination.
      4) Provide (1) CC-2 cable between the prepped hole and the hinge. Provide 6" of wire on the on the panic side for a service loop and install female terminations. Refer to hinge installation instructions for wiring of hinge end.
   b. Based on: Von Duprin, 99/98 series with electric mortise, no QEL
      1) Verification of the hardware installation does not change from the Von Duprin 99/98 series QEL instructions. A wire shall be provided from the mortise straight through the door to the hinge. The mortise shall come with a plug end requiring no additional wires before the hinge. The cable provide with the mortise shall have a plug end as well that resides in the mortise cut. Care shall be taken to not pinch or snip wires. Refer to hinge installation instructions for wiring of hinge end.
   c. Based on: Von Duprin 99/98 series with QEL and ADA operator
      1) Verification and hardware installation of panic hardware dose not change from Von Duprin 99/98 series QEL instructions.
      2) Provide (1) CC-3 cable from the ADA operator and (1) CC-3 cable from ADA operator pushbuttons to the singe gang box location the where cable CC-1 was first split. Connect the CC-3 cable in the ADA operator to the ADA operator trigger. This varies by model. The wires shall be splice back to the CC-4 cable installed back to the access control panel.
      3) The wiring shall be spliced as follows:

PANIC HARDWARE SPLICES	
WIRES SPLICED	CONNECTED TO
CC-4, red & black wires	ADA operator trigger
CC-4 green & white wires	Inside ADA pushbutton
CC-4 brown & blue wires	Outside ADA pushbutton

3. ADA hardware power supply
   a. Based on: PS 902 power supply with 2RS/4rs option board
      1) Verify that 120V power has been installed.
      2) Verify that option board has been included. Power supply WILL NOT work as intended without the option board.
      3) The power supply box shall be hung securely.
      4) Remove (2) knockouts, one on either side of the box. Provide MC or EMT connector in left-side knockout and NM connector or suitable stain-relief In the right-side knockout.
      5) Connect the 120V stand-by power circuit to the left-side connection the of the power supply and terminate conductors per manufacturers instructions.
      6) Connect the purple striped cable of CC-1 cable to the right-side connection of the power supply. Provide enough wire to reach the option board and leave the power supply again to go to the frame.
      7) Cut the purple striped cable of CC-1 and strip back 4" off both sides of purple outer insulation. Terminal block shall be wired as directions state.
      8) In the absence of instructions, the default 2RS option board wiring shall be as connected as follows:

ADA HARDWARE POWER SUPPLY I/O CONNECTIONS	
CONTROL CABLE	OPTION BOARD I/O
CC-1, purple striped cable (access control panel) red wires	I1
CC-1, purple striped cable (access control panel) black wires	SC
CC-1, purple striped cable (frame) red wires	O1
CC-1, purple striped cable (frame) black wires	GND

3.3 FIELD QUALITY CONTROL

A. Upon completion of access control panel mounting, cable installation/terminations and programming, University physical security shall perform access control system inspection and start-up tests.

B. Devices and wiring that do not pass start-up test shall be considered defective.

C. Contractor shall remove and replace defective items furnished and installed under section 1.5 (B)

D. University physical security shall remove and replace defective items furnished and installed under section 1.5 (C).

E. University physical security shall perform system testing until satisfactory operation is achieved. Contractor shall support university physical security for the duration of testing and system is fully operational.

3.4 PROTECTION

A. After installation, protect access control devices from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by the University.

END OF SECTION 281500

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Heat detectors.
5. Notification appliances.
6. Magnetic door holders.
7. Remote annunciator.
8. Addressable interface device.
9. Digital alarm communicator transmitter.

B. Related Requirements:

1. Section 280513 "Conductors and Cables for Electronic Safety and Security" for cables and conductors for fire-alarm systems.

1.2 ACTION SUBMITTALS

A. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; Level III minimum.
    c. Licensed or certified by authorities having jurisdiction.

B. Product Data: For each type of product, including furnished options and accessories.

C. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and 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. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.

6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; 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 required for HVAC unit shutdown on alarm.
    c. Locate detectors according to manufacturer's written recommendations.

12. 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.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Sample warranty.

1.4 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 the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
    b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    c. Complete wiring diagrams showing connections between all devices and equipment.
    d. Riser diagram.
    e. Record copy of site-specific software.
    f. Provide "Inspection and Testing Form" according to the "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.

g. Manufacturer's required maintenance related to system warranty requirements.
h. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

E. 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 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Carbon monoxide detectors.
6. Automatic sprinkler system water flow.
7. Activation of general fire alarm condition of adjacent building (Existing East Gym).

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
7. Recall elevators to primary or alternate recall floors.
8. Activate emergency lighting control.
9. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Loss of communication with any panel on the network.

D. System trouble signal initiation shall 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 any addressable sensor, input module, relay, control module, or remote annunciator.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.

2.3 FIRE-ALARM CONTROL UNIT

MUST BE COMPATIBLE WITH SIEMENS FIRE ALARM PANEL IN EXISTING EAST GYM.

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

C. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class B.
2. Pathway Survivability: Level 0.

D. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

E. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

   a. Elevator lobby detectors except the lobby detector on the designated floor.
   b. Smoke detector in elevator machine room.
   c. Smoke detectors in elevator hoistway.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

F. Remote Smoke-Detector Sensitivity Adjustment: Controls shall 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.

G. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

H. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, [supervisory signals] [supervisory and digital alarm communicator transmitters] [and] [digital alarm radio transmitters] shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

I. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

2.4 MANUAL FIRE-ALARM BOXES

MUST BE COMPATIBLE WITH SIEMENS FIRE ALARM PANEL IN EXISTING EAST GYM.

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38.

1. Single-action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.

2.5 SYSTEM SMOKE DETECTORS

MUST BE COMPATIBLE WITH SIEMENS FIRE ALARM PANEL IN EXISTING EAST GYM.

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the 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 and power-on status.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall 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.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall 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.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.6 CARBON MONOXIDE DETECTORS

A. General: Carbon monoxide detector listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.
2. Testable by introducing test carbon monoxide into the sensing cell.
3. Detector shall provide alarm contacts and trouble contacts.
4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Comply with UL 2075.
6. Locate, mount, and wire according to manufacturer's written instructions.
7. Provide means for addressable connection to fire-alarm system.
8. Test button simulates an alarm condition.

2.7 HEAT DETECTORS

MUST BE COMPATIBLE WITH SIEMENS FIRE ALARM PANEL IN EXISTING EAST GYM.

A. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature or a rate of rise.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.8 NOTIFICATION APPLIANCES

MUST BE COMPATIBLE WITH SIEMENS FIRE ALARM PANEL IN EXISTING EAST GYM.

A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Chimes: Vibrating type.

C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464.

D. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.

1. Mounting: Wall mounted unless otherwise indicated.
2. Flashing shall be in a temporal pattern, synchronized with other units.
3. Strobe Leads: Factory connected to screw terminals.
4. Mounting Faceplate: Factory finished, [red] [white].

2.9 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, 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 shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.10 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to shut down HVAC equipment.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.

2.11 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture [one] [two] telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

E. Smoke- or Heat-Detector Spacing: Comply with NFPA 72.

F. 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.

G. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

H. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

I. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

J. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

L. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.2 PATHWAYS

A. Pathways above recessed ceilings and in non-accessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches above the floor shall be installed in EMT.

B. Pathways shall be installed in EMT.

C. Exposed EMT shall be painted red enamel.

3.3 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.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.5 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.6 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct visual inspection prior to testing.
    a. Inspection shall be based on completed record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. 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.

3.7 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall 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] <Insert number> years 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 access to system and to upgrade computer equipment if necessary.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 283111

SECTION 329113 - FURNISHING AND SPREADING TOPSOIL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide all equipment, labor and materials necessary to perform all work required to install the extent of topsoil as shown on the contract drawings and as required in this specification.

B. Installed topsoil must be 6” minimum depth in all new lawn areas, and minimum 12” depth in entire area of all new plantbeds. Refer to contract drawings for extent of each area.

C. Furnishing and Spreading Topsoil includes furnishing, testing, amendment and spreading of topsoil, whether imported or from an on-site source

1.2 REFERENCES

A. ASTM C-33 – Standard Specification for Concrete Aggregates

B. ASTM D1557: Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort.

C. ASTM D-2974 – Standard Test Method for Organic Content

D. ASTM D-4972 – Standard Test Method for pH Determination

E. ASTM F-1632 – Standard Test Method for Particle Size Analysis

1.3 QUALITY ASSURANCE

A. The contractor shall employ and pay for all costs in connection with having an independent testing facility determine the conformance of soils that will be used on the site with the specifications. These test results will be transmitted to the design professional as submittals prior to commencing work.

B. Binghamton University shall appoint, employ and pay for all costs in connection with an approved independent testing facility to determine conformance of soils with the specifications and submitted product information once the materials have arrived on site. Testing should be coordinated with the University so that samples may be pulled from stockpile and not from installed topsoil as testing results can be inaccurate from spread topsoil samples. (This step is required due to the major discrepancies that have been witnessed between submitted product information and actual materials delivered to Campus project sites in the past) Re-testing required because of non-conformance to specified requirements shall be performed by the same independent firm on instruction by the Design Professional, and payment will be charged to the Contractor.

C. All topsoil, whether imported or on-site, shall be tested and the analysis results will be approved by the Design Professional prior to placement on the site. If more than 1000 cubic yards of topsoil are furnished, an additional sample of topsoil shall be submitted for testing from each additional 1000 cubic yards of topsoil to be used on the project. An

approved independent testing laboratory shall do all testing, and all samples shall be taken and prepared in accordance with their requirements. Analysis shall include:

1. Particle size analysis.
2. Soil classification.
3. Organic matter content.
4. pH
5. PCB content - topsoil containing PCB's will not be approved for use on the project.
6. Recommendations for needed soil additives if the topsoil testing results fall outside the required parameters. Include recommended additive composition, rate and method of application information appropriate to the intended use of the topsoil (landscape plantings, seed or sod lawn, etc.)

D. Preparation of subgrade and subgrade compaction shall be according to Specification Section 312000 - Earthwork and Grading.

E. Soil amendments, if required, shall be tested and analysis approved by DESIGN PROFESSIONAL prior to blending with topsoil.

1. Analysis of sand shall include:
   a) Particle size analysis
   b) Uniformity coefficient
   c) Fineness modulus

2. Analysis of organic matter shall include:
   a) Description of type of organic matter
   b) Ash content
   c) Organic content
   d) Moisture content
   e) Carbon to Nitrogen ratio
   f) pH

F. The Owner shall retain an approved independent testing agency to conduct compaction tests of the subsoil on each new lawn or planting area up to 10,000 square feet in size. On larger areas, one test shall be performed for every 10,000 square feet, or as required by Design Professional. The Owner shall pay for the original tests if test results show that the work meets specifications. Areas that do not meet compaction requirements shall be remediated and tested again until specifications are met, and the costs of remediation and re-testing shall be paid by the Contractor.

1.4 SUBMITTALS

A. Testing laboratory analysis for all topsoil and soil amendments shall be submitted to the Design Professional for approval before any topsoil materials may be used on the project. Testing shall show conformance to all specification requirements. Contractor shall bear the costs for all topsoil and materials testing and shipping of samples during the submittal process. Owner shall pay for all testing of materials that are delivered to the site. Contractor shall pay for any testing or re-submittals if submitted samples or delivered samples are rejected.

B. Submit location plan and number of compaction tests to be performed on lawn or plantbed areas for approval by the Design Professional before testing is undertaken by the owners testing agency.

1. Testing agency will report compaction test results indicating subsoil compaction as measured by Modified Proctor (ASTM D1557) to design professional.
2. If compaction test results do not meet specified tolerances, modify the work and arrange for retesting. Contractor will pay for all testing required to show conformance to specifications after initial failure.

PART 2 - PRODUCTS

2.1 TOPSOIL

A. Topsoil shall be a friable, productive agricultural soil typical of the Binghamton area, with the following characteristics:

1. Particle size analysis:

SIEVE DESIGNATION	PERCENT PASSING
1 inch (25 mm)	100
¼ inch (6.3 mm)	97-100
No. 200 (75 µm)	20-65(of the ¼ inch sieve)

2. Soil classification:
   a. Sandy loam soil, as classified by the U.S. Department of Agriculture, and shall have a textural analysis as determined by ASTM F-1632 as follows:

      Sand: 50 to 75%
      Silt: 5 to 40%
      Clay: 5 to 20%

3. Organic matter content shall be between 4% and 8% by weight, as determined by ASTM D-2974.

4. pH (acidity) shall not be less than 5.5 or greater than 7.6 as determined by ASTM D-4972.

2.2 TOPSOIL AMENDMENTS

A. Sand - if additional sand is needed to meet the specified textural analysis, sand shall be:
   1. ASTM C-33 Concrete Sand with a uniformity coefficient (Cu) less than or equal to 4, and fineness modulus of 2.5 to 3.2.

B. Organic matter - if organic amendments are needed to obtain the specified organic matter content of the topsoil, the organic matter source may be:

1. Canadian sphagnum peat having an ash content not exceeding 15%, as determined by ASTM D-2974, and/or
2. Compost not containing biosolids (sewage sludge) and produced in an in-vessel system and screened to ¾", which meets the following standards:

Ash content	less than 40%
Organic content	minimum 60%
Moisture content	30-60%

Carbon to nitrogen ratio	15:1 to 30:1
pH	6.0–8.0

C. Fertilizer - if fertilizers are recommended by the testing laboratory, fertilizers shall be commercial fertilizers with 50% of their total nitrogen derived from ureaform furnishing a minimum of 3.5% water insoluble nitrogen (3.5% WIN). The balance of the nitrogen shall be present as methylene urea, water soluble urea, nitrate and ammoniacal compounds.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prior to placing the topsoil, verify that no foreign materials or deleterious material or liquid has been deposited in the subsoils. Remove all weeds and undesirable plants including all roots. Remove any contaminated subsoil or foreign material.

B. Harrow or otherwise loosen the subsoil to a depth of eight (8) inches minimum, paying special attention to areas where construction equipment has been driven.

C. Fine grade loosened subsoil using light tracked equipment and the minimum of passes necessary to establish lines, levels, profiles and contours as required by the Drawings. Avoid re-compaction of subsoil.

D. Notify Design Professional when these steps have been completed for visual inspection of prepared areas.

3.2 PLACING TOPSOIL

A. Only place topsoil during dry weather and on dry subgrade.
B. Do not place topsoil if subgrade is frozen.
C. Apply approximately half the thickness of topsoil over prepared, loosened subgrade and mix thoroughly into top 2-4 inches of subgrade material.
D. Place remainder of planting soil.
E. Grade topsoil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake topsoil to remove ridges and fill depressions to meet finished grade.
F. Topsoil shall be installed to such a depth that after natural settlement and light rolling the thickness of the topsoil shall not be less than **six (6) inches for lawn areas and twelve (12) inches for plantbeds**, unless noted otherwise on the Contract Drawings.
G. Any litter, stones larger than ½", or other objectionable material shall be removed from topsoil.

END OF SECTION

SECTION 329200 - SEED LAWN

PART 1 – GENERAL

1.1 DESCRIPTION

A. Provide all equipment, labor and materials necessary to perform all work required to install the extent of seed lawns as shown on the drawings.

B. Seed Lawn includes seeding and establishment of new lawn areas where indicated on the Drawings, and as required to restore all existing lawn areas disturbed by CONTRACTOR'S operations.

1.2 RELATED DOCUMENTS

A. Specification Section 329113 – Furnishing and Spreading Topsoil

1.3 QUALITY ASSURANCE

A. Topsoil and amendments shall be according to Specification Section 329113, and shall be approved by DESIGN PROFESSIONAL prior to application.

B. Installer Qualifications: A qualified landscape installer whose work has resulted in successful seed lawn establishment and has the following qualifications:

1. Is a member of The American Nursery and Landscape Association or The New York State Nursery and Landscape Association or The Professional Landcare Network

2. Has at least 5 years experience in turf installation of a similar scale to the work shown on the contract documents

C. Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

1.4 SUBMITTALS

A. Testing results for all topsoil and soil amendments shall be according to specification section 329113 and shall be submitted to the Design Professional for approval before any materials may be used on the project.

B. Qualification Data of Landscape Installer:

1. ANLA or STNLA or PLN Membership Verification
2. Completed Project list of at least 10 successfully completed seed lawns similar in scale within the last 5 years including location and contact person with phone number.

C. Producer's seed certifications naming seed varieties, proportions, purity and germination, dated within 9 months of sowing. Submit seed certifications that seed meets producer's tests for purity and germination, dated within 9 months of sowing.

D. Submit manufacturer's certification of fertilizer composition

E. Maintenance Data: Recommended procedures to be established by Owner for maintenance of seed lawn during a calendar year.

F. Written guarantee on all newly installed lawn areas for 1 year after all seed is sown.

PART 2 – PRODUCTS

2.1 TOPSOIL

A. Shall be according to Specification Section 329113, and shall be approved by the Design Professional prior to application.

2.2 SEED

A. Seed shall be fresh, clean, dry and of the latest crop year.

B. Include a percentage of weed seed not exceeding 0.1% by weight.

C. Be delivered in unopened bags of the vender, showing the weight, analysis and vendor's name.

D. Be approved by the DESIGN PROFESSIONAL before application.

E. Seed shall be:

Percent in mix, by weight	Variety	Percent Purity	Percent Germination
75	Kentucky Bluegrass Blend	95	80
15	Creeping Red Fescue	98	85
10	Perennial Ryegrass	95	90

1. Use a blend of 3 approved Kentucky Bluegrass varieties, with at least one of a preferred sun-loving variety (Adelphi, Bonnieblue, Nassau, or Ram I) and at least one of a preferred shade-tolerant variety (Chateau, Glade, and Touchdown).

2. Perennial ryegrass shade be of a disease-resistant variety such as Fiesta II, Manhattan II, Navajo, Saturn, or Precision.

F. Seeding rate shall be: 3 pounds per 1,000 square feet

2.3 FERTILZER

A. Delivered in standard sized, unopened bags of the vendor, with weight, analysis, and name of the manufacturer clearly marked.

B. Handled as recommended by manufacturer

C. Fertilizer to be applied after seedling emergence shall be 15-15-15 fertilizer. Fertilizer shall be commercial fertilizer with 50% of total nitrogen derived from ureaform furnishing a minimum of 3.5% water insoluble nitrogen (3.5% WIN).

2.4 MULCHES

A. Shall be free of noxious weed seed.

B. Straw Mulch: Provide air dry, clean, mildew and seed free, mowed wheat, oat or rye straw.

C. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

1. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

PART 3 - EXECUTION

3.1 FIELD CONDITIONS

A. Seeding season shall be April 1 - June 1 for spring seeding and August 15 - October 15 for fall seeding. Extension of seeding dates may be allowed upon written approval from the Design Professional.

B. Seeding shall be done in dry to moderately dry soil, and at a time when the wind speed does not exceed 5 miles per hour

3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

B. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.

C. Protect grade stakes set by others until directed to remove them.

D. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

E. Just before seeding, area to be seeded shall be loosened to a depth of 3 inches and raked to true lines and grades, free from unsightly variations, bumps, ridges, and depressions. Remove all sticks, clods, roots, stones larger than ½ inch, and any other objectionable material, to make an even and finely pulverized seedbed.

3.3 SEEDING

A. Seed shall be mechanically sown at the rate specified for each mixture. Either drill-seeding or hydroseeding is acceptable.
    1. If Drill Seeding:
        a. Apply seed with an approved mechanical seeder.
        b. One half the seed allotted to the area shall be sown in one direction and the balance shall be cross-sown.
        c. After seeding, lightly rake seed into topsoil , covering with not more than 1/8 inch of soil.
        d. In areas exceeding 5:1 slope and in drainage swales, overseed with an additional 3 pounds per 1,000 square feet.
        e. Mulch all areas immediately after seeding. Apply straw mulch evenly at a rate of 100 pounds per 1,000 square feet.
        f. Thoroughly water seeded area with a fine spray.
        g. Apply an approved tackifier over mulch at CONTRACTOR'S option.

    2. If Hydroseeding:
        a. Apply seed with an approved hydroseeder.
        b. Use hydromulch, tackifier and seed according to equipment manufacturer's instructions so as to achieve the specified seeding rates.
        c. Once the seed is in the tank, avoid delays and excessive agitation, which may reduce seed viability.
        d. Distribute slurry mixture uniformly, at a minimum rate of 57 gallons per 1,000 square feet.
        e. In areas exceeding 5:1 slope and in drainage swales, overseed with an additional 3 pounds per 1,000 square feet.

B. Protect all seeded areas with slopes exceeding 1:4 with erosion control blankets installed and stapled according to manufacturers written instructions.

3.4 FERTILIZING

A. Two weeks after seedling emergence, evenly apply single nutrient nitrogen fertilizer at a rate of 0.5 pounds per 1,000 square feet to new lawn areas, and fully water in.

3.5 MAINTENANCE AND PROTECTION

A. Water all seeded areas thoroughly, by approved means, to a depth of 2" soil saturation a minimum of two (2) times per week, or more often when weather conditions warrant it, for a minimum of 30 days or longer, as required to achieve a uniform and healthy stand of the specified grasses, and until final acceptance.
    1. A water source is not part of this contract and therefore Contractor should anticipate the need to provide required water for watering time period.

    2. Lack of water source is not an acceptable reason for not watering newly seeded lawns. Contractor will be responsible for re-seeding and mulching any areas that fail due to dry-out or lack of water.

B. Mow all seeded areas once turf has reached an average height of 3-1/2 inches to maintain a grass height between 2 and 2-1/2 inches. Do not remove more than 40% of grass leaf in a single mowing.

C. Repair all washouts, gullies and areas of unsatisfactory germination that are 8 square inches or larger by replacing topsoil, re-raking, re-seeding, and re-mulching as required.

D. Remove all trash and excess materials from site.

E. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout the maintenance period and remove after lawns are fully established and accepted.

3.6 INSPECTION AND ACCEPTANCE

A. The Contractor shall request the Design Professional to inspect when the lawn is fully established.

B. An acceptable lawn shall be a healthy, relatively smooth, and uniformly established stand of grass 2 or 2-1/2 inches tall that is reasonably weed free.

C. Lawn areas may not contain bare spots that exceed 5” x 5”.

D. Owner is responsible for maintenance of the lawn after final acceptance.

END OF SECTION

SECTION 329210 - SOD LAWN

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. Information pertaining to the supply and installation of sod

1.2 DEFINITIONS

A. Sod Lawn includes supplying and laying sod, and the establishment of new sod lawn where indicated on the Drawings.

1.3 REFERENCES

A. TPI (Turfgrass Producers International) Guideline Specifications for Sodding

1.4 QUALITY ASSURANCE

A. Sod shall be:

1. Commercially grown by a producer specializing in sod production with a minimum of five years experience.

2. Inspected and found free of diseases, nematodes, pests and pest larvae by an entomologist of the State Department of Agriculture.

3. Tagged with common name of each grass species.

4. approved by the DESIGN PROFESSIONAL before application.

B. Topsoil and amendments shall be according to Specification Section – Furnishing and Spreading Topsoil, and shall be approved by DESIGN PROFESSIONAL prior to application.

B. Fertilizer shall be:

1. Delivered in standard sized bags of the vendor, with weight, analysis, and name of the manufacturer clearly marked.
2. Handled as recommended by manufacturer.
3. Approved by the DESIGN PROFESSIONAL before application.

1.4 SUBMITTALS

A. Sod producer's qualifications data:

1. Name, business address, and telephone number
2. Statement certifying producer's experience as required under Quality Assurance above.

B. Sod producers' product data:
1. Statement of grass species and percentages thereof making up the sod
2. Sod certificate of compliance with regulations of the New York State Department of Agriculture and Markets.

C. Submit manufacturer's certification of fertilizer composition.

E. Written guarantee on all newly installed lawn areas for 1 year after sod installation is complete.

D. CONTRACTOR shall bear the costs for all submittals including testing and shipping of samples. CONTRACTOR shall also pay for subsequent testing if submittals are rejected.

1.5 DELIVERY, STORAGE AND HANDLING

A. Protect root system from sun and wind.

B. Do not deliver more sod than can be installed in 24 hours.

C. Store sod in a moistened condition and in shade.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Sod shall:

1. Be a blend of approximately 80% Kentucky Bluegrass and 20% Perennial Ryegrass

2. Bluegrass portion of mix shall be made up of at least three (3) Improved Kentucky Bluegrass varieties, with at least 35% of the seed coming from a shade tolerant variety or varieties.

3. Be field grown in the same climatic conditions as that of the project site.

4. Be grown on mineral soil, NOT peat or muck.

5. Be a minimum of 18 months of age with strong root development.

6. Be free of weeds and undesirable grasses, including Bermuda grass, brome grass, johnson grass, poison ivy, nut sedge, nimble will, Canada thistle, bindweed, bent

grass, wild garlic, ground ivy and perennial sorrel. And shall Contain less than 5 jimsonweed, mustard, lamb's quarter, chickweed, cress or crab grass plants per 100 square feet.

7. Be uniform in color, texture, and leaf density.

8. Have a mowed height when harvested of 1-1/2 to 2-1/2 inches.

9. Thatch shall not exceed ½ inch of thickness uncompressed.

10. Not be less than ½ inch or more than ¾ inch thick, excluding top growth and thatch.

11. Be delivered and placed in big rolls, a minimum of 40 inches wide.

B. Topsoil - Final topsoil material shall meet the requirements of Specification Section – Furnishing and Spreading Topsoil.

C. Fertilizer - Establishment fertilizer shall be applied in the late summer (August 25th - Sept 1st) and shall be a commercial fertilizer 24-3-20 with 50% of the total nitrogen derived from ureaform, furnishing a minimum of 3.5% water insoluble nitrogen (3.5% WIN). The balance of the nitrogen shall be present as methylene urea, water soluble urea, nitrate and ammoniacal compounds. Fertilize at the rate of: .75 lbs/1000 sf of total nitrogen.

PART 3 - EXECUTION

3.1 CONSTRUCTION DETAILS

A. Job conditions:

1. Perform sodding between April 1 and June 1, or August 15 and October 15, unless given written permission by DESIGN PROFESSIONAL.

2. Perform sodding only after preceding work affecting ground surface is completed.

3. Place sod immediately after delivery, within 12 hours in warm weather, up to 36 hours in cooler weather, of its being harvested, unless given written permission by DESIGN PROFESSIONAL.

4. Restrict foot and vehicular traffic from sodded areas after planting to end of established period.

5. Do not sod on frozen, saturated, or dry soil.

6. Do not install sod when temperatures are below 32 degrees F.

B. Before sod is laid, area shall be loosened to a depth of 3 inches and raked to true lines and grades, free from unsightly variations, bumps, ridges, and depressions. Remove all sticks,

clods, roots, stones larger than ½ inch, and any other objectionable material, to make an even and finely pulverized topsoil bed.

C. If topsoil bed is dry, thoroughly moisten to a depth of 3" from 48 to 24 hours prior to sod installation.

D. Lay first row of sod in a straight line with long dimension parallel to slope contours. Butt side and end joints, stagger end joints in adjacent rows. Do not stretch or overlap sod.

E. Peg sod on slopes of 3:1 or greater, using a minimum of two (2) pegs per square yard to prevent sod movement.

F. Water lightly to moisten sod.

G. Roll sod, except on pegged areas, with roller weighing not more than 150 pounds per foot of roller width, making sure all areas of sod are in full contact with the soil below, and the finished surface is smooth and even.

H. Thoroughly and evenly water to a depth of 6 inches immediately after placement and rolling. Water within 30 minutes of installation if weather is hot (temperature above 85º).

I. Install temporary barriers as need to prevent any traffic on newly sodded areas until sod is knitted in and underlying soil is firm enough to resist rutting.

J. Keep sod moist during the ten (10) days after planting. Do not allow sod to dry out. Set any sprinklers so that they can be moved and relocated without walking on the sod to minimize indentations and foot imprints. Where walking on sod is unavoidable, stand on wide boards laid over the sod.

K. Roll seams again approximately ten (10) days after sod was laid.

3.2 MAINTENANCE

A. Water thoroughly, by approved means, to a depth of 2" soil saturation a minimum of two (2) times per week, or more often when weather conditions warrant it, for a minimum of 30 days or longer, as required to achieve a uniform and healthy lawn with roots well knit to the underlying soil, and until final acceptance.

1. A water source is not part of this contract and therefore Contractor should anticipate the need to provide required water for watering time period.

2. Lack of water source is not an acceptable reason for not watering newly seeded lawns. Contractor will be responsible for re-seeding and mulching any areas that fail due to dry-out or lack of water.

B. Four weeks after sod placement, evenly apply single nutrient nitrogen fertilizer (containing 30 - 60% of N in slowly available form) at a rate of 0.5 pounds per 1,000 square feet to new sod lawn areas, and water in.

E. Mow all sodded areas once turf has reached an average height of 3-1/2 inches to maintain a grass height between 2 and 2-1/2 inches. Do not remove more than 40% of grass leaf in a single mowing.

F. Repair all washouts, gullies and areas of unhealthy or dead sod that are 6 square inches or larger by replacing topsoil, re-raking, and patching as required.

G. Remove all trash and excess materials from site.

3.3 INSPECTION AND ACCEPTANCE

A. The Contractor shall request the DESIGN PROFESSIONAL to inspect when the lawn is established. An acceptable lawn shall be a smooth and uniformly established stand of grass 2 - 2-1/2 inches tall that is reasonably weed free, with roots grown into the soil below such that sod pieces cannot be easily lifted. Owner is responsible for maintenance of the lawn, except fertilization, after acceptance of establishment.

B. The Contractor shall be responsible for final establishment fertilization in late summer following which, the lawn shall be accepted. Owner is responsible for all maintenance of the lawn after final acceptance.

END OF SECTION

SECTION 329300 - PLANTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide all equipment, labor and materials necessary to perform all work required to install plantings as shown on the drawings.

B. Section Includes:

1. Plants
2. Fertilizers
3. Mulches
4. Warranty requirements

1.2 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container.

D. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

E. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.

F. Finish Grade: Elevation of finished surface of planting soil.

G. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

H. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

I. Planting Area: Areas to be planted.

J. Topsoil: See Specification 329113 – Furnishing and Spreading Topsoil.

K. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

L. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

M. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

N. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.3 COORDINATION

A. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.

1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.4 SUBMITTALS

A. Product Data: For each type of product.

1. Topsoil: Submit topsoil test results as required by Specification 329113 – Furnishing and Spreading Topsoil.

2. Plant Materials: Submit a detailed breakdown of plant materials to be used on the site that clearly states the scientific name, common name, quantity, size, quality, and sources for each required plant material.

3. Plant Photographs: Submit color photographs in digital or 3 by 5-inch print format of each required species and size of plant material as it will be furnished to Project Site. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than **20** plants are required, include a minimum of **three** photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

B. Samples for Verification: For each of the following:

1. Mulch: Submit a 3 pound sample of each mulch required in a sealed plastic bag labeled with composition of material and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and makeup.

C. Qualification Data: For landscape Installer. Include list of 5 similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, year completed, and names with phone number of owners' contact persons.

D. Sample Warranty

E. Maintenance Requirements: Recommended procedures to be established by Owner for maintenance of plants after the warranty period. **Please note that the Contractor is responsible for maintenance of plants during the warranty period.**

1.5 SUBSTITUTIONS

A. All requested substitutions, must be approved in writing by the Landscape Architect at least ten (10) business days prior to delivery of materials to the site.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants and has the following:

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
2. Experience: At least five years experience in landscape installation
3. Installer's Field Supervision: Installer must maintain an experienced full-time supervisor on Project site while work is in progress.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

C. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.

1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.

2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

D. Plant Material Observation: Landscape Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Landscape Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent

defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Landscape Architect of delivery of planting materials to the project site at least 7 days in advance of delivery.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. 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. Accompany each delivery of bulk materials with appropriate certificates.

C. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

D. Handle planting stock by root ball.

E. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.

F. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

G. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Do not remove container-grown stock from containers before time of planting.
2. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

1.8 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: April 15th – June 30th.
2. Fall Planting: August 15th – October 15th.
3. Planting period extension requests must be submitted in writing for approval by the Landscape Architect.

C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.
1. Planting will not be allowed when the ground is frozen

1.9 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Death and unsatisfactory growth, except for defects resulting from clear abuse.
b. Structural failures including plantings falling or blowing over.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: From date of planting acceptance:

a. Trees, Shrubs, Perennials, Ornamental Grasses, and Ground Covers: twelve months.
b. Annuals: 3 months.

3. Include the following remedial actions as a minimum:

a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

1. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. Labeling: Label **at least one** plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.

2.2 FERTILIZERS

A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
1. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.3 MULCHES

A. Hardwood Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Double shredded Hemlock mulch.
2. Size Range: 3 inches maximum, 1/2 inch minimum.
3. Color: Natural.

B. Stone Mulch: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of the following type, size range, and color:

1. Type: Locally available stone mulch. Provide samples to owner for approval.
2. Size Range: 1-1/2 inches maximum, 3/4 inch minimum.

3. Color: Locally available natural gravel color range. Provide samples to owner for approval.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by the Landscape Architect and replace with new planting soil.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

3.3 PLANTING AREA ESTABLISHMENT

A. General: Prepare topsoil in planting area according to Specification Section 329113 – Furnishing and Spreading Topsoil

B. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.

1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
2. Excavate approximately three times as wide as ball diameter for tree plantings.
3. Excavate approximately two times as wide as container or ball diameter for shrub and perennial plantings
4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
5. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
6. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
7. Maintain supervision of excavations during working hours.
8. Keep excavations covered or otherwise protected when unattended by Installer's personnel.

B. Backfill Soil: Subsoil removed from excavations **may not** be used as backfill soil unless otherwise indicated. Topsoil shall be used for all backfill requirements around new plantings.

C. Obstructions: Notify Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

1. Hardpan Layer: Drill 6-inch diameter holes, 24 inches apart, into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.

D. Drainage: Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

3.5 TREE, SHRUB, AND VINE PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grade.
1. Backfill: Topsoil per Specification Section 329113 – Furnishing and Spreading Topsoil.
2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove

from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.

3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.

    a. Quantity: As specified by tablet manufacturer.

5. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.

1. Backfill: Topsoil
2. Carefully remove root ball from container without damaging root ball or plant.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.

    a. Quantity: As specified by tablet manufacturer.

5. Continue backfilling process. Water again after placing and tamping final layer of soil.

E. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

3.7 PLANTING AREA MULCHING

A. Mulch backfilled surfaces of planting areas and other areas indicated.

1. Apply 3” uniform thickness of new mulch throughout entire plantbed.

2. Apply mulch ring of 3-inch average thickness, with 36-inch radius around trunks or stems of trees. Do not place mulch within 6 inches of trunks or stems.

3.8 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings THROUGHOUT THE WARRANTY PERIOD.
   1. A water source is not part of this contract and therefore Contractor should anticipate the need to provide required water for watering time period.
   2. Lack of water source is not an acceptable reason for not watering newly installed plantings. Contractor will be responsible for plant replacement due to dry-out or lack of water.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

3.9 REPAIR AND REPLACEMENT

A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by the Landscape Architect.

   1. Submit details of proposed pruning and repairs.
   2. Replace trees and other plants that cannot be repaired and restored to full-growth status.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition before the end of the warranty period or are damaged during construction operations that Landscape Architect determines are incapable of restoring to normal growth pattern.

   1. Provide new trees of same size as those being replaced for each tree of 4 inches or smaller in caliper size.
   2. Provide two new trees of 4-inch caliper size for each tree being replaced that measures more than 4 inches in caliper size.
   3. Species of Replacement Trees: Same species being replaced or Species selected by Landscape Architect.

3.10 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

D. After installation and before final acceptance, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

3.11 MAINTENANCE

A. Maintenance for New Plantings: Provide maintenance by skilled employees of landscape Installer. Maintain as required immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:

1. Maintenance Period: 12 months from date of planting completion.

3.12 INSPECTION AND ACCEPTANCE

A. Contractor shall request inspection for initial acceptance of planting by Landscape Architect by giving at least five (5) days notice. This inspection may be on all of the work, or on completed portions of the work.

B. The one year warranty period begins upon initial acceptance by the Landscape Architect.

C. Contractor shall request inspection for final acceptance of planting by Landscape Architect by giving at least five (5) days notice prior to the end of the guarantee period.

END OF SECTION 329300

SECTION 330500 - TRENCHING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide all equipment, labor, and materials, necessary to perform all work required to complete the extent of trenching as shown on the drawings.

B. Trenching includes: excavation of trench, dewatering of excavated areas, installation of bedding material, installation of backfill material, compacting, protection of new and existing work, and disposal, as shown on the Contract Drawings, and as herein specified.

1.2 QUALITY ASSURANCE

A. Perform work in accordance with New York State Department of Transportation (NYSDOT) standard specifications.

B. The Owner shall appoint, employ and pay for all costs in connection with an approved independent testing facility to determine conformance of soils and aggregates with the specifications. Re-testing required because of non-conformance to specified requirements shall be performed by the same independent firm on instruction by the Owners Representative, and payment will be charged to the Contractor.

1.3 SUBMITTALS

A. Material Submittals:

1. Name and location of source
2. Stockpile number if applicable
3. Date of testing - Must be within the last 2 years
4. Material description
5. Gradation results
6. Latest DOT test results and approvals (if any).

B. Information Submittals:

1. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by inadequate performance of excavation support and protection systems. Submit before Work begins.

2. Record Drawings: Identify locations and depths of all expected or discovered utilities, abandoned-in-place support and protection systems, and any other discovered subsurface utilities or structural conditions.

1.4 PROJECT REQUIREMENTS

A. Verify that survey benchmarks and intended elevations for the Work are as indicated.

B. Notify the Owner’s Representative of any unexpected subsurface condition.

C. Protect excavations by shoring, bracing, sheet piling, or by other methods, as required to ensure the stability of the excavation. Comply with current OSHA requirements.

D. Underpin or otherwise support structures adjacent to the excavation which may be damaged by the excavation. This includes utility lines.

E. Protection of Existing Utilities:

1. Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations. Comply with OSHA requirements.

2. Coordinate interruption and/or termination of utilities with the utility companies and the Owner's Representative.

3. Provide a minimum of forty-eight (48) hours notice to the Owner's Representative and receive written notice to proceed before interrupting any utility.

4. Repair any damaged utilities to a condition acceptable to the Owner's Representative, and utility company at no additional cost to the Owner.

F. Protection of Persons and Property:

1. Barricade open excavations occurring as part of this work and post with warning lights, if required.

2. Operate warning lights as recommended by authorities having jurisdiction.

3. Protect structures, utilities, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

4. Perform excavation within 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 conditions for root system and cover exposed roots with burlap. Paint root cuts of 1" diameter and larger with emulsified asphalt tree paint.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Bedding:

1. For Storm Drainage lines shall be:

a. If pipe is NOT perforated - pipe zone bedding shall be NYSDOT No. 1 or No.1A crushed washed stone.

b. If pipe is perforated, pipe zone bedding shall be a 50:50 blend of NYSDOT number 1 and number 2 stone.

2. For water lines shall be NYSDOT No. 1 or No. 1A round stone (pea gravel), or Pipe Bedding Sand according to Specification Section – Aggregates.

B. Trench Backfill:

1. For storm drainage lines and water lines, trench backfill shall be:

a. If pipe is NOT perforated, trench backfill shall be Stone Subbase in accordance with Specification Section - Aggregates.

b. If pipe is perforated, trench backfill shall be a 50:50 blend of NYSDOT number 1 and number 2 stone.

C. Detectable Warning Tape: Acid and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, minimum 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored 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 and Storm systems.

D. Flowable Fill (for abandoning structures to be left in place): Mineral based material which shall fill all the voids when poured into a structure to be abandoned and which shall set up so that it remains in place, but can be removed by machine excavation at a later time.

3 PART 3 EXECUTION

3.1 PREPARATION

A. Establish required lines, levels, contours and datum.

B. Verify subdrainage, damp proofing, or waterproofing installation has been inspected at any nearby structures.

C. Maintain benchmarks and other elevation control points; re-establish if disturbed or destroyed, at no additional cost to the Owner.

D. Establish location and extent of existing utilities prior to commencement of excavation.

E. Do not interfere with 45 degree bearing splay of foundations.

F. Notify Owners Representative of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.

3.2 EXCAVATION

A. All excavation shall be made to such depth as required and of the width shown on the Contract Drawings to provide suitable room for building the structures and laying the pipe(s) they are to contain and for sheeting, shoring, pumping and draining as necessary, and for removing peat, silt, or any other materials.

B. Cut trenches wide enough to allow inspection of installed utilities.

C. Trench excavation for pipes shall be made by open cut to such a depth and width indicated on the Contract Drawings so as to allow a minimum of eight (8) inches of pipe zone bedding to be placed beneath the bottom of all structures and barrels, bells or couplings of all pipes, unless otherwise specified on the drawings.

D. The bottom of the trench shall be accurately graded to provide a uniform layer of bedding material, as required, for each section of pipe. Hand trim and shape trench bottoms and leave free of irregularities, lumps, and projections. Prevent displacement of banks and keep loose soil from falling into excavation; maintain soil stability.

E. Stockpile excavated subsoil for reuse where directed or approved. Remove excess or unsuitable excavated material from site.

F. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.

G. Excavation Below Grade: If, in the opinion of the Owner's Representative, existing material below the trench grade is unsuitable for properly placing bedding material and laying pipe, the Contractor shall excavate and remove the unsuitable material and replace the same with properly compacted Stone subbase according to Specification Section - Aggregates.

H. Stability of Excavation: Slope sides of excavations shall 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 excavation in safe condition until completion of backfilling.

I. Removal of materials beyond the indicated subgrade elevations, without authorization by the Owner's representative, shall be classified as unauthorized excavation and shall be performed at no additional cost to the Owner.

3.3 DEWATERING

A. The Contractor shall review the contents of the Geotechnical Investigation Report that was developed for this project. A copy is included in Division 0 – "Bidding and Contract Requirements" of this Project Manual. The geotechnical investigation and report indicates that there are some areas of high groundwater which may be encountered during construction operations. The Contractor shall include the cost for dewatering operations in the Contract bid price.

B. The Contractor shall remove all water from the excavation promptly and continuously throughout the progress of the work and shall keep the excavation dry at all times until the structures to be built therein are completed and are backfilled or have sufficient weight to resist uplift pressures. Groundwater levels shall be depressed to a minimum of 2 feet below excavation subgrade. No pipe or masonry is to be laid in water and water shall not be allowed to rise on or flow over any pipe or masonry until such time as approved by the Owner's Representative.

C. All necessary precautions shall be taken to prevent disturbances of and to properly drain the subgrades upon which concrete is to be placed and upon which pipe is to be laid. If necessary, in the opinion of the Owner's Representative, well points, deep wells, or other means shall be used to lower the ground-water level, and observation wells shall be installed to confirm that groundwater levels are lowered as specified. Well points, if used, shall be shifted frequently to avoid drainage from too long a distance. Provide a suitable point of discharge in a manner satisfactory to the Owner's representative.

D. Precautions shall be taken to protect uncompleted work from flooding during storms or from other causes. All pipe lines or structures not stable against uplift during construction or prior to completion shall be thoroughly braced or otherwise protected.

3.5 PIPE IDENTIFICATION

A. Install underground detectable warning tape of appropriate color for each type of pipe, at least 6 inches wide with a minimum thickness of 4 mils. The warning tape shall be continuous and buried 12 inches minimum above the pipe, and 30 inches maximum below finished grade. The warning tape shall be located above the pipe centerline and at outside edge of underground structures.

3.6 BEDDING AND BACKFILLING

A. All pipe trenches backfill (pipe zone bedding, pipe zone backfill and trench backfill) shall be compacted by tamping or rolling to achieve a minimum dry density of 95 percent of the ASTM 0698 Proctor maximum dry density of the material used (AASHTO T180-61). Backfill in pipe trenches to be covered with pavement shall be compacted to a minimum of 98 percent of standard Proctor maximum dry density. Backfill materials shall be placed with water content within plus or minus 4 percent of optimum moisture content per the ASTM 0698 Proctor method (AASHTO T180-61). Any water used for compaction shall be provided by the Contractor at his own expense. The approval of the Owner's Representative of the proposed method of compaction of backfill shall in no way be construed as relieving the Contractor of responsibility of settlement of trenches, etc. and any settlement shall be repaired by him at his own expense.

B. Bedding and backfilling shall be accomplished in three stages unless otherwise specified on the Contract Drawings. The first stage shall involve placement of "pipe zone

bedding" as a layer(s) of selected material required to support, or to stabilize unsound or unsatisfactory foundation conditions. The second stage shall involve placement of "pipe zone backfill" from the top of the bedding material up to one (1) foot above the pipe. The third stage involves the placement of "trench backfill" in the remainder of the trench up to the surface of the ground or the bottom of any special surface treatment subgrade elevation.

C. The bedding material shall be placed in the trench after the trench has been excavated a minimum of eight (8) inches below the bell of the pipe to permit the placing of not less than eight (8) inches of bedding material unless otherwise specified on the Contract Drawings. Where, in the opinion of the Owner's Representative, more than eight (8) inches of bedding material shall be required, the excavation shall be performed and bedding placed to the depth ordered by the Owner's Representative.

D. The bedding material shall be placed to the full width of trench. The bedding material shall be placed in loose lifts not exceeding six (6) inches to the elevation shown on the Contract Drawings or directed by the Owner's Representative. The bedding material shall be tamped and compacted to form a firm and even bearing surface.

E. Pipe zone backfill shall be placed to the elevation shown on the Contract Drawings in loose lifts not-to-exceed six (6) inches in thickness, before compaction. The backfill shall be placed on both sides of the pipe at the same time and to approximately the same elevation. Any pipe that is damaged or moved out of alignment, regardless of cause, shall be replaced or realigned at the Contractor's expense. Each layer shall be thoroughly compacted by hand-tamping, or mechanical means being careful not to damage the pipe. When the pipe zone backfill reaches one (1) foot over the top of the pipe, the entire surface shall be compacted by mechanical means.

F. The remainder, if any, of the trench above the pipe zone backfill shall be backfilled with material according to 2.1.B "Trench Backfill" above, in loose lifts not exceeding six (6) inches in thickness before compaction. Each layer shall be thoroughly compacted by mechanical means.

3.6 BACKFILLING AROUND STRUCTURES

A. The Contractor shall not place backfill against any structure without obtaining the approval of the Owner's Representative. No dumping shall be allowed where materials would flow against or around such structures. Backfill material shall be deposited in horizontal layers not exceeding 8 inches in loose thickness or as shown on the Contract Drawings and thoroughly compacted by hand or pneumatic tampers to the satisfaction of the Owner's Representative.

3.7 SUSPENSION OF WORK

A. Whenever the work is suspended, excavations shall be protected and the roadways, if any, left unobstructed. Within or adjacent to private property, material shall be stored at such locations as will not unduly interfere with traffic of any nature and in no case shall materials be stored in locations which will cause damage to existing improvements.

3.8 DISPOSAL OF MATERIAL

A. Excess and unsuitable materials shall be landfilled by the Contractor on the site in an area on-site approved by the Owner's Representative or disposed of off-site at the Contractors expense. Any loam, material of a high clay content, or material containing a high percentage of organic material which the Owner's Representative declares to be unsuitable for backfill shall be replaced at the Contractor's expense.

3.9 FIELD QUALITY CONTROL

A. Notify the Owner's Representative at least one (1) working day in advance of all phases of filling and backfilling operations.

B. In-place density testing shall be performed to ascertain the compacted density of the fill and backfill materials in accordance with the following methods:

1. In-place relative density:
   a. Method: AASHTO T238, Nuclear Method

C. In-place density tests on trench backfills shall be provided for every 500 cubic yards of fill and in vertical lifts not exceeding two (2) feet, and at least once daily.

D. One particle size analysis (ASTM D422) and one Modified Proctor compaction test (AASHTO T180-61) shall be competed for every 5,000 cubic yards of material placed.

E. The Owner's Representative may direct additional tests to establish gradation, maximum density, and in-place density as required by working conditions, at the Contractor's expense.

F. Acceptance Criteria: The criteria for acceptability of in-place fill shall be in-situ dry density and moisture content. If a test fails to qualify, the fill shall be further compacted and re-tested. Subsequent test failures shall be followed by removal and replacement of the material.

END OF SECTION

SECTION 331000 - SITE WATER DISTRIBUTION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Pipe and fittings for site water distribution
2. Valves.
3. Underground pipe markers.
4. Bedding and cover materials.

1.2 REFERENCES

A. American Water Works Association:
1. AWWA C509 - Resilient-Seated Gate Valves for Water-Supply Service.
AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
2. AWWA C651 - Disinfecting Water Mains.

1.3 SUBMITTALS

A. Product Data: Submit data on pipe materials, pipe fittings, valves and accessories.

B. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of piping mains, valves, connections, thrust restraints, and invert elevations.

B. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.5 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Perform Work in accordance with local standards and specifications.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store materials in shipping containers with labeling in place.

PART 2 PRODUCTS

2.1 WATER PIPING

A. Ductile Iron Pipe

1. Centrifugally cast, in accordance with ANSI/AWWA C151/A21.51.

    a. Working Pressure: 100 psi.
    b. Thickness Class: Under 6 inch - 51; 6 inch and larger - 50.
    c. Restrained joints: Boltless integral restraining system rated for a working pressure of 350 psi in accordance with the performance requirements of ANSI/AWWA C111/A21.1.
        1) Field LOK 350 by U.S. Pipe
        2) Flex-Ring by American Pipe
    d. Laying Lengths: 18 or 20 feet.

2. Coating and Lining:
    a. Outside Coating: Bituminous enamel, minimum thickness 1 mil.
    b. Inside Lining: Cement mortar; ANSI/AWWA C104/A21.4.

2.2 FITTINGS

A. Ductile Iron (3 inches – 48 inches): ANSI/AWWA C110/A21.10

B. Compact Ductile Iron Fittings (3 inches – 64 inches): ANSI/AWWA C153/A21.53

C. Joints: Match pipe furnished

D. Coating and Lining:
1. Outside Coating: Bituminous enamel, minimum thickness 1 mil.
2. Inside Lining: Cement mortar; ANSI/AWWA C104/A21.4

2.3 VALVES - BASIC CONSTRUCTION

A. Provide valves of first quality, free from all imperfections and defects, with body markings indicating manufacturer and rating. Valve parts of the same manufacturer, size and type shall be interchangeable. Manually operated valves shall open in a counter-clockwise direction, and in general, round ventilated type handwheels shall be provided. All valves that use packing (except butterfly, cone, and ball valves) shall be capable of being packed when wide open and under full working pressure.

B. Provide valves of each type from a single manufacturer.

C. Unless otherwise indicated, provide valves having a minimum operating pressure of 150 psig OWG, factory tested at double the working pressure.

D. Valve ends, unless otherwise indicated, shall be:
1. Mechanical joint, rubber ring joint, or flanged joint in cast iron/ductile iron piping to match joints of pipe furnished.
2. Valve flanges shall be of a class to mate with pipe flanges.

2.4 GATE VALVES

A. Gate Valves 2 Inches and Larger in Size:

1. Approved model is the Series 405-NRS-RW by Watts Water Technologies.
2. Approved equal to Watts model will be acceptable.
3. Design Standard: ASTM A536.
    a. Comply fully with Standard and the following additional requirements.
    b. Handwheel operators or 2-inch square operating nuts as required.
    c. Valves buried in the ground shall be non-rising stem.
    d. Provide extension stems and guides as required by the location.

2.5 UNDERGROUND PIPE MARKERS

A. Plastic Ribbon Tape: Bright colored, continuously printed, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

B. Trace Wire: Magnetic detectable conductor, brightly colored plastic covering.

2.6 BEDDING AND COVER MATERIALS

A. Bedding: Stone Subbase Course as described in Section 321123 - Aggregates. Bedding shall be 6 inches in depth.

B. Cover: Stone Subbase Course as described in Section 321123 - Aggregates. Cover shall be 12 inches in depth.

C. Trench Backfill from above cover layer to finished grade:
    1. If pipe is installed below lawn areas backfill may be suitable material from excavations. Material shall contain no rocks over 6 inches in diameter, frozen earth, or foreign matter. Leave 6” at top of trench for new topsoil layer for lawn repair.
    2. If pipe is installed below pavements backfill shall be Stone Subbase Course as described in Section 321123 – Aggregates.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify building service connections and existing utility water main sizes, locations, and inverts are as indicated on Drawings.

3.2 PREPARATION

A. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare pipe connections to equipment with flanges or unions.

3.3 BEDDING

A. Place bedding material at trench bottom, level fill materials in one continuous layer not exceeding 8 inches compacted depth; compact to 95 percent.

B. Backfill around sides and to top of pipe with cover fill, tamp in place and compact to 95 percent.

C. Maintain optimum moisture content of fill material to attain required compaction density.

3.4 INSTALLATION – PIPE

A. General: Unless otherwise shown, or specified, install the Work of this Section in accordance with ANSI/AWWA Standard C600 and the manufacturer's printed instructions.

B. Laying Pipe:
1. Maintain separation of ten feet between water main and any sewer lines.
2. Route pipe in straight lines.
3. Lay pipe to line and grade with joints close and even. Excavate adequate bell holes to facilitate joint assembly and to permit a uniform bearing on undisturbed earth for the pipe barrel. Unless otherwise noted minimum depth of pipe shall be 5'-0" measured from the top of the pipe to the finished or existing grade, whichever is lower.
4. Keep the trench free from water. Do not lay or test pipe in a wet trench.
5. Lay water pipe on a continuously rising grade from low points to high points at service lines, hydrants or air valves.
6. Construct concrete thrust blocks behind bends, tees, caps and plugs, as shown on the drawings. Cast concrete against undisturbed earth and place support so it will not interfere with making joints.
7. Use clamps, tie-rods, lugged pipe, etc., for anchorage when required and as approved.
8. Install plastic ribbon tape continuous one foot over top of pipe.
9. Install trace wire continuous attached to top of pipe.

C. Push-on Joints: Make joints with a rubber ring and sterile lubricant. The materials used shall be free of water, oil, tar, grease or other foreign substances.

D. Mechanical Joints: Conform strictly to the manufacturer's instructions with particular reference to gland alignment and the tightening of the bolts.

E. Cutting: Cut pipe at right angles to the axis with sharp tools. Prepare ends for proper connections. Do not lay cut pipe within three lengths of a bend or the end of a line without written approval.

F. Protecting Pipe:
1. Keep pipe clean from all sediment, debris, packing material and other foreign material.
2. Close all open ends of pipes and fittings securely with removable plugs at end of each work day, during storms, and when the Work is left at any time.

G. PRESSURE AND LEAKAGE TESTS

1. Before backfilling, fill pipe with water to expel all air. Conduct as directed concurrent pressure and leakage tests for two hours at 1-1/2 times the specified working pressure. Maximum variation in test pressures shall not exceed plus or minus 5 psi.
2. Test Procedures: ANSI/AWWA C600, Section 5.

3.5 INSTALLATION - VALVES

A. Set valves on compacted soil.

B. Center and plumb valve box over valve. Set box cover flush with finished grade.

3.6 INSTALLATION - SERVICE CONNECTIONS

A. Install water service in accordance with local regulations

3.7 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Flush and disinfect system in accordance with American Water Works Association AWWA C651.

3.8 FIELD QUALITY CONTROL

A. Perform pressure test on domestic site water distribution system in accordance with AWWA C600.

B. Compaction testing for bedding, cover, and trench backfill: In accordance with ASTM D1557.

C. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

D. Frequency of Compaction Tests: Every 50 cubic yards of backfill placed.

END OF SECTION

SECTION 331100 - SANITARY SEWER PIPING

1 PART 1 GENERAL

1.1 SECTION INCLUDES

A. Sanitary sewage piping: gravity lines.

B. Connection of gravity sewers to existing and/or proposed structures.

1.2 REFERENCES

A. ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

B. ASTM D 3034 - Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.

1.3 DEFINITIONS

A. Bedding and Cushion: Fill placed under, beside and directly over pipe, prior to subsequent backfill operations.

1.4 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data indicating pipe, pipefittings, pipe accessories, and manholes and covers.

C. Manufacturer's Installation Instructions: Indicate special procedures required to install Products specified.

D. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

2 PART 2 PRODUCTS

2.1 SEWER PIPE MATERIALS

A. Gravity Sewer Pipe: Plastic Pipe, ASTM D 1785, Schedule 40, Poly Vinyl Chloride (PVC) solid and/or perforated material; inside nominal diameter of 4, 6 and 8 inches, solvent sealed joints.

B. Vent Pipe: Plastic Pipe, ASTM D 1785, Schedule 80, Poly Vinyl Chloride (PVC) solid material; inside nominal diameter of 4 and 6 inches, solvent sealed joints.

C. Fittings: Same material as pipe molded or formed to suit pipe size and end design, in required tee, bends, elbows, reducers and other configurations required.

2.2 PIPE ACCESSORIES

A. Trace Wire: Magnetic detectable conductor, clear plastic covering, imprinted with "Sewer Service" in large letters.

2.3 BEDDING AND COVER MATERIALS

A. Pipe Bedding Material: As specified in Trenching Specification.

B. Pipe Cover Material: As specified in Trenching Specification.

3 PART 3 EXECUTION

3.1 TRENCHING

A. See Trenching Specification for additional requirements.

B. Hand trim excavation for accurate placement of pipe to elevations indicated.

C. Backfill around sides and to top of pipe with Pea Stone, tamp in place and compact, then complete backfilling.

3.2 INSTALLATION - PIPE

A. Verify that trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on drawings.

B. Install pipe, fittings, and accessories in accordance with ASTM D 2321 and manufacturer's instructions. Seal joints watertight.

C. Lay pipe to slope gradients noted on drawings with a maximum variation from true slope of 1/16 inch in 10 feet.

D. Connect to existing building sanitary sewer outlet and proposed structures as necessary.

E. Test all solid PVC gravity sewer lines prior to backfilling, using low-pressure air to prove the integrity of the installed material and the construction procedures. The testing shall be completed in conformance with ASTM F-1417 – "Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air".

F. Install trace wire 12 inches above top of pipe; coordinate with Section 02316.

G. Backfill in accordance with Section 02316.

3.3 FIELD QUALITY CONTROL

A. Perform field inspection and testing in accordance with Section 01400.

3.4 PROTECTION

A. Protect pipe and bedding cover from damage or displacement until backfilling operation is in progress.

END OF SECTION

SECTION 334100 - STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings.
2. Manholes
3. Catch Basins

1.2 SUBMITTALS

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

B. Shop Drawings:
1. **Catch basins** - Include plans, elevations, sections, details, frames, covers, and grates.

1.3 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.

C. Handle catch basins according to manufacturer's written rigging instructions.

1.4 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service is required for this project: Only interrupt service to facilities occupied by University under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify University no fewer than 48 hours in advance of proposed interruption of service.
2. Do not proceed with interruption of service without written permission from the University.

PART 2 - PRODUCTS

2.1 PE PIPE AND FITTINGS

A. Corrugated HDPE Drainage Pipe and Fittings NPS 3 to NPS 10: AASHTO M 252M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.
2. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.

B. Corrugated HDPE Pipe and Fittings NPS 12 to NPS 60: AASHTO M 294M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
2. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

2.2 MANHOLES

A. Standard Precast Concrete Manholes:

1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: 48 inches minimum unless otherwise indicated.
3. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.
4. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
5. Riser Sections: 4-inch minimum thickness, and lengths to provide depth indicated.
6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated, and top of cone of size that matches grade rings.
7. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
8. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
9. Steps: Wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than **60 inches**.
10. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.

B. Manhole Frames and Covers:

1. Description: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch-minimum width flange and 26-inch-diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."
2. Material: **ASTM A 48/A 48M, Class 35 gray** iron unless otherwise indicated.

2.3 CATCH BASINS

A. Standard Precast Concrete Catch Basins:

1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
3. Riser Sections: 4-inch minimum thickness, and lengths to provide depth indicated.
4. Top Section: Flat slab top with opening size that matches frame and grate.
5. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
6. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
7. Steps: Wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of catch basin to finished grade is less than **60 inches.**
8. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.

B. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include flat grate with small square or short-slotted drainage openings.

1. Size: 24 by 24 inches minimum unless otherwise indicated.
2. Grate Free Area: Approximately 50 percent unless otherwise indicated.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install 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. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow.
2. Install piping **NPS 6**and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.
3. Install piping with 24 **inch**minimum cover unless noted otherwise on drawings.
4. Install PE corrugated sewer piping according to ASTM D 2321.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:
1. Join corrugated PE piping according to ASTM D 3212 for push-on joints.

3.4 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.

D. Set tops of frames and covers flush with finished grade.

3.5 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

3.6 IDENTIFICATION

A. Materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use warning tape or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.7 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:

    a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
    d. Infiltration: Water leakage into piping.
    e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

    a. Exception: Piping with soiltight joints unless required by authorities having jurisdiction.

C. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.8 CLEANING

A. Clean interior of piping of dirt and superfluous materials. **Flush with water.**

END OF SECTION 334100

SECTION 334600 - GEOTEXTILES

1 PART 1 GENERAL

1.1 DESCRIPTION

A. Contractor shall provide and place geotextiles noted in this section as required by applicable codes, good standard engineering practice, soils conditions encountered and the approved site design.

1.2 SUBMITTALS

A. Product Data:
   1. Manufacturer's catalog sheets, specifications, and installation instructions.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Protect filter fabric from sunlight during transportation and storage.

2 PART 2 PRODUCTS

2.1 MATERIALS

A. Geotextile shall be the type listed below, shown on the Drawings, or an approved equal.

   1. Drainage and Erosion Control Fabric (WINFAB 700N or approved equal): shall be nonwoven geotextile, specifically manufactured as a drainage geotextile, made from polyolefin, polyesters, or polyamides; and with the following minimum properties determined according to latest ASTM testing methods or referenced standard test methods:

      a. Grab Tensile Strength: 180 lbs; ASTM D 4632.

      b. Trapezoidal Tear Strength: 75 lbs; ASTM D 4533.

      c. Puncture Resistance: 105 lbs; ASTM D 4833.

      d. Water Flow Rate: 100 gpm per sq. ft.; ASTM D 4491.

      e. Apparent Opening Size: No. 70; ASTM D 4751.

   2. Separation and Stabilization Fabric under pavements: (WINFAB 315W, or approved equal): Woven geotextile, specifically manufactured for use as a separation and stabilization geotextile; made from polyolefin, polyesters, or polyamides; and with the following minimum properties determined according to latest ASTM testing methods or referenced standard test methods:

      a. Grab Tensile Strength: 315 lbs; (ASTM D 4632).

      b. Trapezoidal Tear Strength: 120 lbs; ASTM D 4533.

c. Puncture Resistance: 150 lbs; ASTM D 4833.

d. Water Flow Rate: 4 gpm per sq. ft.; ASTM D 4491.

e. Apparent Opening Size: No. 40; ASTM D 4751.

B. Acceptable equivalents:

1. For WINFAB 700N: Nonwoven geotextile fabric approved by the New York State Department of Transportation for use as a drainage fabric in all soil classes (A,B, and C) and listed on the NYSDOT Approved Materials list.

2. For WINFAB 315W: Woven geotextile fabric approved by the New York State Department of Transportation for use as a separation and stabilization fabric and listed on the NYSDOT Approved Materials list.

3 PART 3 EXECUTION

3.1 CONSTRUCTION DETAILS

A. The subgrade shall be cleared of all sharp objects and approved by the DESIGN PROFESSIONAL before placement of the geotextile.

B. Place and overlap filter fabric in accordance with the manufacturer's installation instructions, unless otherwise shown.

C. Cover tears and other damaged areas with additional filter fabric layer extending 3 feet beyond the damage.

D. Do not permit traffic or construction equipment directly on filter fabric.

E. Backfill over filter fabric within two weeks after placement. Backfill in accordance with the fabric manufacturer's instructions and in a manner to prevent damage to the fabric.

END OF SECTION

Limited Pre-Renovation Asbestos Survey Report

Performed at:

Binghamton University East Gym Addition
4400 Vestal Parkway East
Binghamton, New York 13902

Prepared for:

BINGHAMTON UNIVERSITY
State University of New York

Mr. Brian Aylward, Asbestos Coordinator
Binghamton University
Department of Physical Facilities
PO Box 6000
Binghamton, NY 13902

Prepared by:

DELTA
ENGINEERS, ARCHITECTS, & SURVEYORS

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Delta Project No. 2022.619.001

Field work performed by:
William T. Johnson, and Greg Umbra: June 21st, 2022 & August 31st, 2023

Report prepared by:
Shawn May: September 11th, 2023

Report reviewed by:
William T. Johnson: October 11th, 2023

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1.0 INTRODUCTION:

Delta Engineers, Architects, & Land Surveyors (Delta) was contracted by Binghamton University to provide a limited pre-renovation asbestos survey the Bathroom of the Binghamton University East Gym Addition located on the Binghamton University Campus in Binghamton, New York. This survey was performed to identify asbestos containing materials (ACM's) present at the structure that may be impacted by the upcoming Renovation Project. On June 21st, 2023 & August 21st, 2023 Delta representatives William T. Johnson, and Greg Umbra were on site to perform a walkthrough to visually inspect all accessible spaces/areas of the areas scheduled for renovation as well as perform material sampling.

Based on a visual inspection of the proposed renovation areas, a total of seventy-six (76) bulk samples were collected representing thirty-eight (38) separate suspect homogenous materials. Forty-six (46) samples were Non-Friable Organically Bound (NOB) representing twenty-three (23) homogenous materials. The remaining thirty (30) samples were "Non-NOB" materials representing fifteen (15) homogenous material. The suspect homogenous building materials identified at the West Gym Boiler Room included:

Homogenous Area (HA)	Suspect Building Material
01	Gray Exterior Expansion Joint Caulk
02	Gray Ceramic Floor Tile Grout from Blue 2"x2"
03	Gray Ceramic Floor Tile Mortar/Adhesive from Blue 2"x2"
04	White Sink/Counter Caulk
05	Tan Ductwork Seam Caulk
06	White Fiberglass End Cap Mastic
07	Sheetrock Ceiling
08	Joint Compound from Sheetrock Ceiling
09	Counter Back Splash Adhesive
10	Green Ceramic Floor Tile Mortar/Adhesive from Pink 2"x2"
11	Gray Ceramic Floor Tile Grout from Pink 2"x2"
12	Brown Interior Window Frame/Trim Caulk
13	Gray Perimeter Floor Slab Caulk
14	Brown Exterior Door/Window Frame/Trim Caulk
15	Gray Column Cap Grout
16	Gray Column Cap Mortar
17	Black Expansion Joint Material - Between Sidewalk and East Gym Building
18	Gray Sidewalk Caulk
19	Gray Lower Roof Soffit Caulk
20	Gray Sheetrock - 2nd Floor Weight Room
21	White Joint Compound - 2nd Floor Weight Room
22	White Cove Base Mastic from Black Cove Base -2nd Floor Weight Room
23	White FRP Panel Mastic
24	Gray Sheetrock - Men's Locker Room
25	White Joint Compound - Men's Locker Room
26	2'x2' Pin Hole Ceiling Tile
27	Gray 2'x2' Ceramic Tile Grout

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Area (HA)	Homogenous Suspect Building Material Continued:
28	Blue Epoxy Flooring
29	Gray Interior Window Frame Caulk
30	Black Roof Seam Sealant
31	White Gypsum Board Under EPDM At Roof Edge Flashing
32	Tan Adhesive From ISO Board Paper At Roof Edge Flashing
33	Black Vapor Barrier Under ISO Board At Roof Edge Flashing
34	Black Hot Mop Under Vapor Barrier At Roof Edge Flashing
35	White Gypsum Board Under EPDM - Main Field
36	Tan Adhesive From ISO Board Paper - Main Field
37	Black Vapor Barrier Under ISO Board - Main Field
38	Black Hot Mop Under Vapor Barrier - Main Field

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Specific information required by 12 NYCRR Part 56-5.1, (f) – "Building/Structure Asbestos Survey Information" to be included in this pre-demolition survey report is as follows:

1) Building Name/Address:	East Gym Binghamton University 4400 Vestal Parkway East Binghamton, New York 13902
2) Owner's Name/Address:	Binghamton University 4400 Vestal Parkway East Binghamton, New York 13902
3) Owner's Agent:	Mr. Brain Aylward, Asbestos Coordinator Department of Physical Facilities Binghamton University
4) Survey Performed By:	Delta Engineers Architects & Land Surveyors' PC. 860 Hooper Road Endwell, NY 13760
5) Certified Inspectors:	William T. Johnson Certificate No. 88-05722 Greg Umbra Certificate No. 93-08135
6) Date(s) of Survey:	June 21st, 2023 & August 31st, 2023
7) Laboratory:	America Science Team New York, Inc. 117 East 30th Street, New York, NY 10016

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2.0 ASBESTOS SURVEY AND SAMPLING PROCEDURES AND METHODS:

2.1 Survey requirements

Requirements to perform Pre-Demolition/Pre-Renovation Asbestos Surveys are based on the following State and Federal Regulations.

Occupational Safety and Health Administration (OSHA): OSHA survey requirements and sampling protocols are included in 29 CFR Part 1910.1001(j)(2) & (j)(8) and 29 CFR Part 1926.1101(k),(5):

29 CFR Part 1910.1001(j)(2), Installed Asbestos Containing Material: Employers and building owners are required to treat installed TSI and sprayed on and troweled-on surfacing materials as ACM in buildings constructed no later than 1980 for purposes of this standard. These materials are designated "presumed ACM or PACM", and are defined in paragraph (b) of this section. Asphalt and vinyl flooring material installed no later than 1980 also must be treated as asbestos-containing. The employer or building owner may demonstrate that PACM and flooring material do not contain asbestos by complying with paragraph (j)(8)(iii) of this section.

29 CFR Part 1910.1001(j)(8), Criteria to rebut the designation of installed material as PACM:
***1910.1001(j)(8)(i) -** At any time, an employer and/or building owner may demonstrate, for purposes of this standard, that PACM does not contain asbestos. Building owners and/or employers are not required to communicate information about the presence of building material for which such a demonstration pursuant to the requirements of paragraph (j)(8)(ii) of this section has been made. However, in all such cases, the information, data, and analysis supporting the determination that PACM does not contain asbestos, shall be retained pursuant to paragraph (m) of this section.*

***1910.1001(j)(8)(ii) -** An employer or owner may demonstrate that PACM does not contain asbestos by the following:*
***1910.1001(j)(8)(ii)(A) -** Having a completed inspection conducted pursuant to the requirements of AHERA (40 CFR 763, Subpart E) which demonstrates that no ACM is present in the material; or*

*1910.1001(j) (8) (ii) (B) **-** Performing tests of the material containing PACM which demonstrate that no ACM is present in the material. Such tests shall include analysis of bulk samples collected in the manner described in 40 CFR 763.86. The tests, evaluation and sample collection shall be conducted by an accredited inspector or by a CIH. Analysis of samples shall be performed by persons or laboratories with proficiency demonstrated by current successful participation in a nationally recognized testing program such as the National Voluntary Laboratory Accreditation Program (NVLAP) or the National Institute for Standards and Technology (NIST) or the Round Robin for bulk samples administered by the American Industrial Hygiene Association (AIHA) or an equivalent nationally-recognized round robin testing program.*

*1910.1001(j)(8)(iii) **-**The employer and/or building owner may demonstrate that flooring material including associated mastic and backing does not contain asbestos, by a determination of an industrial hygienist based upon recognized analytical techniques showing that the material is not ACM.*

29 CFR Part 1926.1101(k)(5), Criteria to rebut the designation of installed material as PACM:
1926.1101(k)(5)(i) - At any time, an employer and/or building owner may demonstrate, for purposes of this standard, that PACM does not contain asbestos. Building owners and/or employers are not required to communicate information about the presence of building material for which such a demonstration pursuant to the requirements of paragraph (k)(5)(ii) of this section has been made. However, in all such cases, the information, data, and analysis supporting the determination that PACM does not contain asbestos, shall be retained pursuant to paragraph (n) of this section.

1926.1101(k)(5)(ii) – An employer or owner may demonstrate that PACM does not contain more than 1 percent asbestos by the following:
1926.1101(k)(5)(ii)(A) - Having a completed inspection conducted pursuant to the requirements of AHERA (40 CFR Part 763, Subpart E) which demonstrates that the material is not ACM; or

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1926.1101(k) (5) (ii) (B) - Performing tests of the material containing PACM which demonstrate that no ACM is present in the material. Such tests shall include analysis of bulk samples collected in the manner described in 40 CFR 763.86. The tests, evaluation and sample collection shall be conducted by an accredited inspector or by a CIH. Analysis of samples shall be performed by persons or laboratories with proficiency demonstrated by current successful participation in a nationally recognized testing program such as the National Voluntary Laboratory Accreditation Program (NVLAP) or the National Institute for Standards and Technology (NIST) or the Round Robin for bulk samples administered by the American Industrial Hygiene Association (AIHA) or an equivalent nationally-recognized round robin testing program.

1926.1101(k)(5)(iii) - The employer and/or building owner may demonstrate that flooring material including associated mastic and backing does not contain asbestos, by a determination of an industrial hygienist based upon recognized analytical techniques showing that the material is not ACM.

EPA National Emissions Standard for Hazardous Air Pollutants (NESHAPs): (NESHAPs) regulates asbestos under "40 CFR Part 61, Subpart M - National Emission Standard for Asbestos". Subpart M regulates demolition and/or renovation of "facilities" that may contain asbestos-containing materials (ACMs). "Facilities," as defined by NESHAPs, includes any institutional, commercial, public, industrial, or residential structure or building, *except* residential buildings having four or fewer units. ACMs are defined in NESHAPs as materials containing more than 1 percent asbestos. Section 61.145 states:

61.145 Standard for demolition and renovation.
(a) Applicability. To determine which requirements of paragraphs (a), (b), and (c) of this section apply to the owner or operator of a demolition or renovation activity and prior to the commencement of the demolition or renovation, thoroughly inspect the affected facility or part of the facility where the demolition or renovation operation will occur for the presence of asbestos, including Category I and Category II nonfriable ACM.

It should be noted that 40 CFR Part 1 Subpart M, NESHAPS has no cut-off date exempting survey requirements.

New York State Department of Labor (NYS DOL): Guidelines followed for the inspection are those established by the NYS DOL's Industrial Code Rule 56 (Cited as 12 NYCRR Part 56, as amended, adopted January 11, 2006; effective September 5, 2006). The specific survey, sampling and reporting requirements included in 12 NYCRR Part 56-5.1(e) – "Building/Structure Asbestos Survey Requirements" include:

56-5.1 Asbestos Survey Requirements for Building/Structure Demolition, Renovation, Remodeling and Repair

(a) **Asbestos Survey Required.** An owner or an owner's agent, except the owner of one and two-family dwellings who contracts for, but does not direct or control the work, shall cause to be conducted, an asbestos survey completed by a licensed asbestos contractor using inspectors certified in compliance with Section 56-3.2(d), to determine whether or not the building or structure, or portion(s) thereof to be demolished, renovated, remodeled, or have repair work, contains ACM, PACM or asbestos material. This asbestos survey shall be completed and submitted as indicated in Subdivision (g) of this Section, prior to commencing work. All such asbestos surveys shall be conducted in conformance with the requirements of Subdivision (e) of this Section.

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(b) **Exemptions to Asbestos Survey Requirements**: The asbestos survey required by this Subdivision (a) of this Section shall not be required for the following classes of buildings or structures:

(1) An agricultural building;

(2) Buildings or structures for which original construction commenced on or after January 1, 1974;

(3) A structure certified in writing to be structurally unsound by a licensed Professional Engineer, Registered Architect, Building Inspector, Fire Inspector or other official of competent jurisdiction. (See Section 56-11.5)

(c) **Building/Structure Demolition**. If a building/structure asbestos survey is not required or performed per Subdivision (b) of this Section, and the building/structure is certified to be unsound or slated for contracted demolition, the building/structure shall be assumed to contain asbestos, and shall be demolished per this Part, unless the building/structure is adequately certified to be free of asbestos containing material. Acceptable documentation for certification shall be a previous thorough building/structure asbestos survey, abatement records or other documentation acceptable to the Commissioner or his or her representative.

(d) **Responsibility to Comply.** No exemption to the requirement to conduct an asbestos survey shall exempt any person, asbestos contractor, property owner or business entity from the inspection or asbestos survey requirements of EPA, OSHA, and any other applicable section of this Part.

(e) **Building/Structure Asbestos Survey Requirements.** The asbestos survey shall include a thorough inspection for and identification of all PACM, suspect miscellaneous ACM, or asbestos material throughout the building/structure or portion thereof to be demolished, renovated, remodeled, or to have repair work. The required inspection shall be performed by a certified asbestos inspector, and, at a minimum, shall include identification of PACM, suspect miscellaneous ACM or asbestos material by all of the following methods:

(1) The review of building/structure plans and records, if available, for references to asbestos, ACM, PACM, suspect miscellaneous ACM or asbestos material used in construction, renovation, or repair; and

(2) A visual inspection for PACM and suspect miscellaneous ACM throughout the building/structure or portion thereof to be demolished, renovated, remodeled, or repaired. For the purpose of this Part, all PACM and suspect miscellaneous ACM visually assessed shall be treated and handled as ACM and shall be assumed to be ACM, unless bulk sampling is conducted as per this Section, standard EPA and OSHA accepted methods, including multi-layered systems sampling protocols; the subsequent analyses are performed by a laboratory that meets the requirements of Section 56-4.2 of this Part; and the analyses satisfies both ELAP and federal requirements, including multi-layered sample analyses, to document non-asbestos containing material.

(f) **Building/Structure Asbestos Survey Information.**

(1) The asbestos survey shall, at a minimum, identify and assess with due diligence, the locations, quantities, friability, and conditions of all types of installations at the affected portion of the building/structure relative to the ACM, suspect miscellaneous ACM, PACM or asbestos material contained therein. The following list is not inclusive of all types of ACMs, it only summarizes typical ACMs. The certified asbestos inspector is responsible for identification and assessment of all

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types of ACM, PACM, suspect miscellaneous ACM and asbestos material within the affected portion of the building/structure:

PACM

(i) **Surfacing Treatments:**

(a) Fireproofing;
(b) Acoustical Plaster;
(c) Finish Plasters; and
(d) Skim Coats of Joint Compound.

(ii) **Thermal System Insulation:**

(a) Equipment Insulation;
(b) Boiler, Breeching, Boiler Rope, Duct, or Tank Insulation, Cement or Mortar Used for Boilers and Refractory Brick;
(c) Piping and Fitting Insulations including but not limited to, Wrapped Paper, Aircell, Millboard, Rope, Cork, Preformed Plaster, Job Molded Plaster, and coverings over fibrous glass insulation.

SUSPECT MISCELLANEOUS ACM

(i) **Roofing and Siding Miscellaneous Materials:**

(a) Insulation Board;
(b) Vapor Barriers;
(c) Coatings;
(d) Non-Metallic or Non-Wood Roof Decking
(e) Felts;
(f) Cementitious Board (Transite);
(g) Flashing;
(h) Shingles; and
(i) Galbestos.

(ii) **Other Miscellaneous Materials:**

(a) Dust and Debris;
(b) Floor Tile;
(c) Cove Base;
(d) Floor Leveler Compound;
(e) Ceiling Tile;
(f) Vermiculite Insulation
(g) Gaskets, Seals, Sealants (including for condensate control);
(h) Vibration Isolators;
(i) Laboratory Tables and Hoods;
(j) Chalkboards;
(k) Pipe Penetration Packing or Other Firestopping Materials
(l) Cementitious Board;
(m) Electrical Wire Insulation;
(n) Fire Curtains;
(o) Fire Blankets;
(p) Fire Doors;
(q) Brakes and Clutches;
(r) Mastics, Adhesives and Glues;
(s) Caulks;
(t) Sheet Flooring (Linoleum);

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(u) Wallpaper;
(v) Drywall;
(w) Plasterboard
(x) Spackling/Joint Compound;
(y) Textured Paint;
(z) Grout;
(aa) Glazing Compound; and
(ab) Terrazzo.

(2) All ACM, PACM, suspect miscellaneous ACM, or asbestos material reported under Paragraph (1) of this Subdivision shall include the location of the materials, an estimate of the quantities, types, friability, and condition of the identified materials to be treated and handled as ACM. For the purpose of this Part, all PACM and suspect miscellaneous ACM visually assessed shall be treated and handled as ACM and shall be assumed to be ACM, unless bulk sampling is conducted as per this Section, standard EPA and OSHA accepted methods, including multilayered systems sampling protocols; the subsequent analyses are performed by a laboratory that meets the requirements of Section 56-4.2 of this Part; and the analyses satisfies both ELAP and federal requirements, including multi-layered sample analyses, to document non-asbestos containing material.
(3) The building/structure asbestos survey shall also include the building/structure name, address, the building/structure owner's name and address, the name and address of the owner's agent, the name of the firm performing the asbestos survey and a copy of the firm's current asbestos handling license, the names of the certified inspector(s) performing the survey and a copy of the current asbestos handling certificate for each inspector utilized, the dates of the asbestos survey, a listing of homogeneous areas identifying which ones are ACM, all laboratory analyses reports for bulk samples collected, and copies of the appropriate certifications for the laboratory used for analysis of samples taken during the asbestos survey.

(g) **Transmittal of Building/Structure Asbestos Survey Information.** One (1) copy of the results of the building/structure asbestos survey shall be immediately transmitted by the building/structure owner as follows:

(1) One (1) copy of the completed asbestos survey shall be sent by the owner or their agent to the local government entity charged with issuing a permit for such demolition, renovation, remodeling or repair work under applicable State or local laws.
(2) The completed asbestos survey for controlled demolition (as per Subpart 56-11.5) or pre-demolition asbestos projects shall also be submitted to the appropriate Asbestos Control Bureau district office.
(3) The completed asbestos survey shall be kept on the construction site with the asbestos notification and variance, if required, throughout the duration of the asbestos project and any associated demolition, renovation, remodeling, or repair project.

(h) **Removal Required.** If the building/structure asbestos survey finds that the portion of the building/structure to be demolished, renovated, remodeled, or have repair work contains ACM, PACM, suspect miscellaneous ACM assumed to be ACM, or asbestos material, which is impacted by the work, the owner or the owner's agent shall conduct, or cause to have conducted, asbestos removal performed by a licensed asbestos abatement contractor in conformance with all standards set forth in this Part. All ACM, PACM, suspect miscellaneous ACM assumed to be

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ACM, or asbestos material impacted by the demolition, renovation, remodeling, or repair project shall be removed as per this Part, prior to access or disturbance by other uncertified trades or personnel. No demolition, renovation, remodeling, or repair work shall be commenced by any owner or the owner's agent prior to the completion of the asbestos abatement in accordance with the notification requirements of this Part. For multi-phased work, the access restriction for uncertified trades or personnel applies to each intermediate portion of the entire project. Upon completion of the intermediate portion of the asbestos project, other trades or personnel may access that portion of the work site.

For demolition projects that are exempt from asbestos survey requirements due to being structurally unsound, the demolition is considered an asbestos project and shall proceed as per Section 56-11.5.

(1) All building/structure owners and asbestos abatement contractors on a demolition, renovation, remodeling, or repair project, which includes work covered by this Part, shall inform all trades on the work site about PACM, ACM, asbestos material and suspect miscellaneous ACM assumed to be ACM at the work site.

(i) **Bidding.** Bids may be advertised and contracts awarded for demolition, remodeling, renovation, or repair work, but no work on the current intermediate portion of the project shall commence on the demolition, renovation, remodeling or repair work by any owner or agent prior to completion of all necessary asbestos abatement work for the current intermediate portion of the entire project, in conformance with all standards set forth in this Part.

(j) **Unidentified and Unassessed Asbestos.** When any construction activity, such as demolition**,** remodeling, renovation or repair work, reveals PACM or suspect miscellaneous ACM that has not been identified by the asbestos survey per this Part, or has not been identified by other inspections as per current OSHA or EPA requirements, all activities shall cease in the area where the PACM or suspect miscellaneous ACM is found and the Asbestos Control Bureau shall be notified by telephone by the building/structure owner or their representative, followed with a written notice in accordance with the notification requirements of this Part. Unassessed PACM or suspect miscellaneous ACM shall be treated and handled as ACM and assumed to be ACM, unless proven otherwise by standard EPA and OSHA accepted methods, including multi-layered systems sampling protocols; subsequent analyses performed by a laboratory that meets the requirements of Section 56-4.2 of this Part; and the analyses satisfies both NYS ELAP and federal requirements, including multi-layered sample analyses, to document non-asbestos containing material.

2.2 Sample Analysis

Bulk sample analysis was performed by American Science Team New York Inc., an independent laboratory approved/accredited by the NYS Department of Health (ELAP), the American Industrial Hygiene Association (AIHA), and the National Voluntary Laboratory Accreditation Program (NVLAP).

Samples collected during the course of this survey fell into one of two categories. The first category includes non-friable organically bound (NOB) materials. These materials are those which have an organic binder in their matrix and include items such as floor tiles, sheet flooring, mastics,

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glazings, caulks and roofing materials. The second category includes non-NOB "friable" materials including parging, sheetrock, joint compound, wall insulations, and wallboard.

Analysis of all "NOB" materials and ceiling tiles were initially performed by Polarized Light Microscopy (PLM) following the New York State Department of Health ELAP 198.6 Gravimetric Reduction Methodology. If a given sample was reported as non-asbestos following this analysis, it was then analyzed by Transmission Electron Microscopy (TEM) following the NYS DOH ELAP 198.4 Methodology.

Analysis of all "non-NOB" materials was performed by Polarized Light Microscopy (PLM) following the EPA 600/M4/82/020 and the NYS DOH ELAP 198.1 Methodologies.

2.3 Materials not sampled

There were several materials present at the site which were not considered "suspect" by the inspector and were not sampled. These included various fiberglass, foam, vinyl, silicone, wood/cellulose products, and concrete/cinder block/brick components.

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3.0 SURVEY FINDINGS AND CONCLUSIONS

3.1) Binghamton University East Gym, Binghamton NY, Limited Pre-Renovation Asbestos Survey, Non-Asbestos Materials - The following materials were sampled as a part of the "Limited" Pre-Renovation Asbestos Survey and reported as "Non-Asbestos":

Homogenous Area (HA)	Suspect Building Material
01	Gray Exterior Expansion Joint Caulk
02	Gray Ceramic Floor Tile Grout from Blue 2"x2"
03	Gray Ceramic Floor Tile Mortar/Adhesive from Blue 2"x2"
04	White Sink/Counter Caulk
05	Tan Ductwork Seam Caulk
06	White Fiberglass End Cap Mastic
07	Sheetrock Ceiling
08	Joint Compound from Sheetrock Ceiling
09	Counter Back Splash Adhesive
10	Green Ceramic Floor Tile Mortar/Adhesive from Pink 2"x2"
11	Gray Ceramic Floor Tile Grout from Pink 2"x2"
12	Brown Interior Window Frame/Trim Caulk
13	Gray Perimeter Floor Slab Caulk
14	Brown Exterior Door/Window Frame/Trim Caulk
15	Gray Column Cap Grout
16	Gray Column Cap Mortar
17	Black Expansion Joint Material - Between Sidewalk and East Gym Building
18	Gray Sidewalk Caulk
19	Gray Lower Roof Soffit Caulk
20	Gray Sheetrock - 2nd Floor Weight Room
21	White Joint Compound - 2nd Floor Weight Room
22	White Cove Base Mastic from Black Cove Base -2nd Floor Weight Room
23	White FRP Panel Mastic
24	Gray Sheetrock - Men's Locker Room
25	White Joint Compound - Men's Locker Room
26	2'x2' Pin Hole Ceiling Tile
27	Gray 2'x2' Ceramic Tile Grout
28	Blue Epoxy Flooring
29	Gray Interior Window Frame Caulk
30	Black Roof Seam Sealant
31	White Gypsum Board Under EPDM At Roof Edge Flashing
32	Tan Adhesive From ISO Board Paper At Roof Edge Flashing
33	Black Vapor Barrier Under ISO Board At Roof Edge Flashing
34	Black Hot Mop Under Vapor Barrier At Roof Edge Flashing
35	White Gypsum Board Under EPDM - Main Field
36	Tan Adhesive From ISO Board Paper - Main Field
37	Black Vapor Barrier Under ISO Board - Main Field
38	Black Hot Mop Under Vapor Barrier - Main Field

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3.2) Binghamton University East Gym, Binghamton, NY, Limited Pre-Renovation Asbestos Survey, Asbestos-Containing Materials – Results reported for samples collected during this survey have determined that for the affected spaces addressed and associated materials sampled as a part of this survey, **none** of materials sampled were found to be an asbestos-containing material (ACM).

4.0 INACCESSIBLE AREAS

This Survey was performed in accordance with 12 NYCRR Part 56, which references the application of "due diligence" during the identification and assessment of materials, i.e. a reasonable standard of care will be applied based upon training and experience. Performing this Survey in full compliance with the applicable statutory code does not guarantee that every asbestos-containing material will be identified.

Only the areas/spaces referenced in Section 1.0 of this report which were visible and accessible were inspected and sampled as a part of this survey. Inaccessible areas such as wall cavities, enclosed wall chases, wet-walls and fixed/hard ceiling plenum spaces could not be inspected without select demolition. Any materials present in the areas not accessible should be assumed ACM when encountered, until tested.

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APPENDIX A

Asbestos Bulk Sample Report Forms

ENGINEERS, ARCHITECTS, & SURVEYORS

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Client: Binghamton University	**Client Project/Purchase Order No.:**	**Delta Proj. No.:** 2022.619.001
Project: East Gym Addition and Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey	**Date Sampling Performed:** 6/21/2023 & 8/31/2023	**Asbestos Inspector(s):** W.Johnson & G.Umbra
	Date of Report: 08/08/2023	**Number of Samples Collected:** 76
	Laboratory: AmeriSci, NY Labs	**Number of Samples Analyzed:** PLM - 76 / TEM - 46

Asbestos Bulk Sample Report Form

Sample Number		HA*	Floor	Bulk Sample Description / Details	Material Type	Asbestos Type	PLM Result % Asbestos	TEM Result % Asbestos
2022.619.001 -	01A	01	1	Gray Exterior Expansion Joint Caulk - Exterior Bathroom	Miscellaneous	ND	ND	ND
2022.619.001 -	01B	01	1	Gray Exterior Expansion Joint Caulk - Exterior Bathroom	Miscellaneous	ND	ND	ND
2022.619.001 -	02A	02	1	Gray Ceramic Floor Tile Grout from Blue 2"x2" - Exterior Men's Room	Miscellaneous	ND	ND	NA
2022.619.001 -	02B	02	1	Gray Ceramic Floor Tile Grout from Blue 2"x2" - Exterior Men's Room	Miscellaneous	ND	ND	NA
2022.619.001 -	03A	03	1	Gray Ceramic Floor Tile Mortar/Adhesive from Blue 2"x2" - Exterior Men's Room	Miscellaneous	ND	ND	NA
2022.619.001 -	03B	03	1	Gray Ceramic Floor Tile Mortar/Adhesive from Blue 2"x2" - Exterior Men's Room	Miscellaneous	ND	ND	NA
2022.619.001 -	04A	04	1	White Sink/Counter Caulk - Exterior Men's Room	Miscellaneous	ND	ND	ND
2022.619.001 -	04B	04	1	White Sink/Counter Caulk - Exterior Ladies Room	Miscellaneous	ND	ND	ND
2022.619.001 -	05A	05	1	Tan Ductwork Seam Caulk - Exterior Bathroom Mechanical Room	Miscellaneous	ND	ND	ND
2022.619.001 -	05B	05	1	Tan Ductwork Seam Caulk - Exterior Bathroom Mechanical Room	Miscellaneous	ND	ND	ND
2022.619.001 -	06A	06	1	White Fiberglass End Cap Mastic - Exterior Bathroom Mechanical Room	Miscellaneous	ND	ND	ND
2022.619.001 -	06B	06	1	White Fiberglass End Cap Mastic - Exterior Bathroom Mechanical Room	Miscellaneous	ND	ND	ND
2022.619.001 -	07A	07	1	Sheetrock Ceiling - Exterior Men's Room	Miscellaneous	ND	ND	NA

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	Date of Report: 08/08/2023	**Number of Samples Collected:** 76
	Laboratory: AmeriSci, NY Labs	**Number of Samples Analyzed:** PLM - 76 / TEM - 46

Asbestos Bulk Sample Report Form

Sample Number		HA*	Floor	Bulk Sample Description / Details	Material Type	Asbestos Type	PLM Result % Asbestos	TEM Result % Asbestos
2022.619.001 -	07B	07	1	Sheetrock Ceiling - Exterior Ladies Room	Miscellaneous	ND	ND	NA
2022.619.001 -	08A	08	1	Joint Compound from Sheetrock Ceiling - Exterior Men's Room	Miscellaneous	ND	ND	NA
2022.619.001 -	08B	08	1	Joint Compound from Sheetrock Ceiling - Exterior Ladies Room	Miscellaneous	ND	ND	NA
2022.619.001 -	09A	09	1	Counter Back Splash Adhesive - Exterior Men's Room	Miscellaneous	ND	ND	ND
2022.619.001 -	09B	09	1	Counter Back Splash Adhesive - Exterior Ladies Room	Miscellaneous	ND	ND	ND
2022.619.001 -	10A	10	1	Green Ceramic Floor Tile Mortar/Adhesive from Pink 2"x2" - Exterior Ladies Room	Miscellaneous	ND	ND	NA
2022.619.001 -	10B	10	1	Green Ceramic Floor Tile Mortar/Adhesive from Pink 2"x2" - Exterior Ladies Room	Miscellaneous	ND	ND	NA
2022.619.001 -	11A	11	1	Gray Ceramic Floor Tile Grout from Pink 2"x2" - Exterior Ladies Room	Miscellaneous	ND	ND	NA
2022.619.001 -	11B	11	1	Gray Ceramic Floor Tile Grout from Pink 2"x2" - Exterior Ladies Room	Miscellaneous	ND	ND	NA
2022.619.001 -	12A	12	1	Brown Interior Window Frame/Trim Caulk - Exterior Men's Room	Miscellaneous	ND	ND	ND
2022.619.001 -	12B	12	1	Brown Interior Window Frame/Trim Caulk - Exterior Ladies Room	Miscellaneous	ND	ND	ND
2022.619.001 -	13A	13	1	Gray Perimeter Floor Slab Caulk - Exterior Bathroom Mechanical Room	Miscellaneous	ND	ND	ND
2022.619.001 -	13B	13	1	Gray Perimeter Floor Slab Caulk - Exterior Bathroom Mechanical Room	Miscellaneous	ND	ND	ND

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Project: East Gym Addition and Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey	**Date Sampling Performed:** 6/21/2023 & 8/31/2023	**Asbestos Inspector(s):** W.Johnson & G.Umbra
	Date of Report: 08/08/2023	**Number of Samples Collected:** 76
	Laboratory: AmeriSci, NY Labs	**Number of Samples Analyzed:** PLM - 76 / TEM - 46

Asbestos Bulk Sample Report Form

Sample Number		HA*	Floor	Bulk Sample Description / Details	Material Type	Asbestos Type	PLM Result % Asbestos	TEM Result % Asbestos
2022.619.001 -	14A	14	1	Brown Exterior Door/Window Frame/Trim Caulk - Exterior Men's Room	Miscellaneous	ND	ND	ND
2022.619.001 -	14B	14	1	Brown Exterior Door/Window Frame/Trim Caulk - Exterior Ladies Room	Miscellaneous	ND	ND	ND
2022.619.001 -	15A	15	1	Gray Column Cap Grout - East Gym Exterior Wall	Miscellaneous	ND	ND	NA
2022.619.001 -	15B	15	1	Gray Column Cap Grout - East Gym Exterior Wall	Miscellaneous	ND	ND	NA
2022.619.001 -	16A	16	1	Gray Column Cap Mortar - East Gym Exterior Wall	Miscellaneous	ND	ND	NA
2022.619.001 -	16B	16	1	Gray Column Cap Mortar - East Gym Exterior Wall	Miscellaneous	ND	ND	NA
2022.619.001 -	17A	17	1	Black Expansion Joint Material - Between Sidewalk and East Gym Building	Miscellaneous	ND	ND	ND
2022.619.001 -	17B	17	1	Black Expansion Joint Material - Between Sidewalk and East Gym Building	Miscellaneous	ND	ND	ND
2022.619.001 -	18A	18	1	Gray Sidewalk Caulk - East Gym Entrance	Miscellaneous	ND	ND	ND
2022.619.001 -	18B	18	1	Gray Sidewalk Caulk - East Gym Entrance	Miscellaneous	ND	ND	ND
2022.619.001 -	19A	19	1	Gray Lower Roof Soffit Caulk - East Gym Building	Miscellaneous	ND	ND	ND
2022.619.001 -	19B	19	1	Gray Lower Roof Soffit Caulk - East Gym Building	Miscellaneous	ND	ND	ND
2022.619.001 -	20A	20	2	Gray Sheetrock - 2nd Floor Weight Room East Gym Building	Miscellaneous	ND	ND	NA

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	Date of Report: 08/08/2023	**Number of Samples Collected:** 76
	Laboratory: AmeriSci, NY Labs	**Number of Samples Analyzed:** PLM - 76 / TEM - 46

Asbestos Bulk Sample Report Form

Sample Number		HA*	Floor	Bulk Sample Description / Details	Material Type	Asbestos Type	PLM Result % Asbestos	TEM Result % Asbestos
2022.619.001 -	20B	20	2	Gray Sheetrock - 2nd Floor Weight Room East Gym Building	Miscellaneous	ND	ND	NA
2022.619.001 -	21A	21	2	White Joint Compound - 2nd Floor Weight Room East Gym Building	Miscellaneous	ND	ND	NA
2022.619.001 -	21B	21	2	White Joint Compound - 2nd Floor Weight Room East Gym Building	Miscellaneous	ND	ND	NA
2022.619.001 -	22A	22	2	White Cove Base Mastic from Black Cove Base -2nd Floor Weight Room East Gym	Miscellaneous	ND	ND	ND
2022.619.001 -	22B	22	2	White Cove Base Mastic from Black Cove Base -2nd Floor Weight Room East Gym	Miscellaneous	ND	ND	ND
2022.619.001 -	23A	23	2	White FRP Panel Mastic - 2nd Floor Weight Room East Gym Building	Miscellaneous	ND	ND	ND
2022.619.001 -	23B	23	2	White FRP Panel Mastic - 2nd Floor Weight Room East Gym Building	Miscellaneous	ND	ND	ND
2022.619.001 -	24A	24	1	Gray Sheetrock - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	NA
2022.619.001 -	24B	24	1	Gray Sheetrock - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	NA
2022.619.001 -	25A	25	1	White Joint Compound - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	NA
2022.619.001 -	25B	25	1	White Joint Compound - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	NA
2022.619.001 -	26A	26	1	2'x2' Pin Hole Ceiling Tile - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	ND
2022.619.001 -	26B	26	1	2'x2' Pin Hole Ceiling Tile - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	ND

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Client: Binghamton University	**Client Project/Purchase Order No.:**	**Delta Proj. No.:** 2022.619.001
Project: East Gym Addition and Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey	**Date Sampling Performed:** 6/21/2023 & 8/31/2023	**Asbestos Inspector(s):** W.Johnson & G.Umbra
	Date of Report: 08/08/2023	**Number of Samples Collected:** 76
	Laboratory: AmeriSci, NY Labs	**Number of Samples Analyzed:** PLM - 76 / TEM - 46

Asbestos Bulk Sample Report Form

Sample Number		HA*	Floor	Bulk Sample Description / Details	Material Type	Asbestos Type	PLM Result % Asbestos	TEM Result % Asbestos
2022.619.001 -	27A	27	1	Gray 2'x2' Ceramic Tile Grout - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	NA
2022.619.001 -	27B	27	1	Gray 2'x2' Ceramic Tile Grout - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	NA
2022.619.001 -	28A	28	1	Blue Epoxy Flooring - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	ND
2022.619.001 -	28B	28	1	Blue Epoxy Flooring - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	ND
2022.619.001 -	29A	29	1	Gray Interior Window Frame Caulk - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	ND
2022.619.001 -	29B	29	1	Gray Interior Window Frame Caulk - Men's Locker Room East Gym Building	Miscellaneous	ND	ND	ND
2022.619.001 -	30A	30	Ext	Black Roof Seam Sealant - Roof Edge - North	Miscellaneous	ND	ND	ND
2022.619.001 -	30B	30	Ext	Black Roof Seam Sealant - Roof Edge - North	Miscellaneous	ND	ND	ND
2022.619.001 -	31A	31	Ext	White Gypsum Board Under EPDM At Roof Edge Flashing - Northwest	Miscellaneous	ND	ND	NA
2022.619.001 -	31B	31	Ext	White Gypsum Board Under EPDM At Roof Edge Flashing - Northeast	Miscellaneous	ND	ND	NA
2022.619.001 -	32A	32	Ext	Tan Adhesive From ISO Board Paper At Roof Edge Flashing - Northwest	Miscellaneous	ND	ND	ND
2022.619.001 -	32B	32	Ext	Tan Adhesive From ISO Board Paper At Roof Edge Flashing - Northeast	Miscellaneous	ND	ND	ND
2022.619.001 -	33A	33	Ext	Black Vapor Barrier Under ISO Board At Roof Edge Flashing - Northwest	Miscellaneous	ND	ND	ND

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Project: East Gym Addition and Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey	**Date Sampling Performed:** 6/21/2023 & 8/31/2023	**Asbestos Inspector(s):** W.Johnson & G.Umbra
	Date of Report: 08/08/2023	**Number of Samples Collected:** 76
	Laboratory: AmeriSci, NY Labs	**Number of Samples Analyzed:** PLM - 76 / TEM - 46

Asbestos Bulk Sample Report Form

Sample Number		HA*	Floor	Bulk Sample Description / Details	Material Type	Asbestos Type	PLM Result % Asbestos	TEM Result % Asbestos
2022.619.001 -	33B	33	Ext	Black Vapor Barrier Under ISO Board At Roof Edge Flashing - Northeast	Miscellaneous	ND	ND	ND
2022.619.001 -	34A	34	Ext	Black Hot Mop Under Vapor Barrier At Roof Edge Flashing - Northwest	Miscellaneous	ND	ND	ND
2022.619.001 -	34B	34	Ext	Black Hot Mop Under Vapor Barrier At Roof Edge Flashing - Northwest	Miscellaneous	ND	ND	ND
2022.619.001 -	35A	35	Ext	White Gypsum Board Under EPDM - Main Field - Northwest	Miscellaneous	ND	ND	NA
2022.619.001 -	35B	35	Ext	White Gypsum Board Under EPDM - Main Field - Northeast	Miscellaneous	ND	ND	NA
2022.619.001 -	36A	36	Ext	Tan Adhesive From ISO Board Paper - Main Field - Northwest	Miscellaneous	ND	ND	ND
2022.619.001 -	36B	36	Ext	Tan Adhesive From ISO Board Paper - Main Field - Northeast	Miscellaneous	ND	ND	ND
2022.619.001 -	37A	37	Ext	Black Vapor Barrier Under ISO Board - Main Field - Northwest	Miscellaneous	ND	ND	ND
2022.619.001 -	37B	37	Ext	Black Vapor Barrier Under ISO Board - Main Field - Northwest	Miscellaneous	ND	ND	ND
2022.619.001 -	38A	38	Ext	Black Hot Mop Under Vapor Barrier - Main Field - Northwest	Miscellaneous	ND	ND	ND
2022.619.001 -	38B	38	Ext	Black Hot Mop Under Vapor Barrier - Main Field - Northwest	Miscellaneous	ND	ND	ND

HA - Homogenous Area **ND** - No Asbestos Detected **NA** - Not Analyzed by Methodology **NA/PS** - Not Analyzed, Positive Stop
TSI - Thermal System Insulation **Misc.** - Miscellaneous Material **Trace / < 1%** - Non-asbestos by definition

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APPENDIX B

Laboratory Analytical Results

AmeriSci New York
117 EAST 30TH ST.
NEW YORK, NY 10016
TEL: (212) 679-8600 • FAX: (212) 679-3114

PLM Bulk Asbestos Report

Delta Engineers
Attn: Stephen Prislupsky
860 Hooper Road

Endwell, NY 13760

Date Received 06/22/23 **AmeriSci Job #** 223063257
Date Examined 06/23/23 **P.O. #**
ELAP # 11480 **Page** 1 **of** 11
RE: 2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-01A 01	223063257-01 **Location:** 1st Fl., Exterior Bathroom - Gray Ext. Expansion Joint Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 17.7%			
2022.619.001-01B 01	223063257-02 **Location:** 1st Fl., Exterior Bathroom - Gray Ext. Expansion Joint Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 18.4%			
2022.619.001-02A 02	223063257-03 **Location:** 1st Fl., Exterior Men's Room - Gray Ceramic Floor Tile Grout From Blue 2" x 2"	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-02B 02	223063257-04 **Location:** 1st Fl., Exterior Men's Room - Gray Ceramic Floor Tile Grout From Blue 2" x 2"	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-03A 03	223063257-05 **Location:** 1st Fl., Exterior Men's Room - Gray Ceramic Floor Tile Mortar / Adhesive From Blue 2" x 2"	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Dark Green, Homogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-03B 03	223063257-06 **Location:** 1st Fl., Exterior Men's Room - Gray Ceramic Floor Tile Mortar / Adhesive From Blue 2" x 2"	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Dark Gray/Green, Heterogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-04A 04	223063257-07 **Location:** 1st Fl., Exterior Men's Room - White Sink / Counter Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: White, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 11.9%			
2022.619.001-04B 04	223063257-08 **Location:** 1st Fl., Exterior Ladies Room - White Sink / Counter Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: White, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 3.8%			
2022.619.001-05A 05	223063257-09 **Location:** 1st Fl., Exterior Bathroom, Mechanical Room - Tan Ductwork Seam Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Tan, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 9.8%			
2022.619.001-05B 05	223063257-10 **Location:** 1st Fl., Exterior Bathroom, Mechanical Room - Tan Ductwork Seam Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Tan, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 10.4%			
2022.619.001-06A 06	223063257-11 **Location:** 1st Fl., Exterior Bathroom, Mechanical Room - White Fiberglass End Cap Mastic	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: White/Yellow, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 17.4%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-06B 06	223063257-12 **Location:** 1st Fl., Exterior Bathroom, Mechanical Room - White Fiberglass End Cap Mastic	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: White/Yellow, Heterogeneous, Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Fibrous glass 3%, Non-fibrous 13.6%			
2022.619.001-07A 07	223063257-13 **Location:** 1st Fl., Exterior Men's Room - Ceiling Sheetrock	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Brown/White, Heterogeneous, Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose 25%, Fibrous glass Trace, Non-fibrous 75%			
2022.619.001-07B 07	223063257-14 **Location:** 1st Fl., Exterior Ladies Room - Ceiling Sheetrock	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Brown/White, Heterogeneous, Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose 13%, Fibrous glass Trace, Non-fibrous 87%			
2022.619.001-08A 08	223063257-15 **Location:** 1st Fl., Exterior Men's Room - Joint Compound From Ceiling Sheetrock	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: White, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-08B 08	223063257-16 **Location:** 1st Fl., Exterior Ladies Room - Joint Compound From Ceiling Sheetrock	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: White, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-09A 09	223063257-17 **Location:** 1st Fl., Exterior Men's Room - Counter Backsplash Adhesive	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Tan/White, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 14.6%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-09B 09	223063257-18 **Location:** 1st Fl., Exterior Ladies Room - Counter Backsplash Adhesive	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Tan/White, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 13.5%			
2022.619.001-10A 10	223063257-19 **Location:** 1st Fl., Exterior Ladies Room - Green Ceramic Floor Tile Mortar / Adhesive From Pink 2" x 2"	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Dark Green, Homogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-10B 10	223063257-20 **Location:** 1st Fl., Exterior Ladies Room - Green Ceramic Floor Tile Mortar / Adhesive From Pink 2" x 2"	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Dark Green, Homogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-11A 11	223063257-21 **Location:** 1st Fl., Exterior Ladies Room - Gray Ceramic Floor Tile Grout From Pink 2" x 2"	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: White/Gray, Heterogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-11B 11	223063257-22 **Location:** 1st Fl., Exterior Ladies Room - Gray Ceramic Floor Tile Grout From Pink 2" x 2"	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: White/Gray, Heterogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-12A 12	223063257-23 **Location:** 1st Fl., Exterior Men's Room - Brown Interior Window Frame / Trim Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Dark Brown, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 5.8%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-12B 12	223063257-24 **Location:** 1st Fl., Exterior Ladies Room - Brown Interior Window Frame / Trim Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Dark Brown, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 6.7%			
2022.619.001-13A 13	223063257-25 **Location:** 1st Fl., Exterior Bathroom Mechanical Room - Gray Perimeter Floor Slab Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 11%			
2022.619.001-13B 13	223063257-26 **Location:** 1st Fl., Exterior Bathroom Mechanical Room - Gray Perimeter Floor Slab Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 12.2%			
2022.619.001-14A 14	223063257-27 **Location:** 1st Fl., Exterior Men's Room - Brown Exterior Door / Window Frame / Trim Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Dark Brown, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 9.3%			
2022.619.001-14B 14	223063257-28 **Location:** 1st Fl., Exterior Ladies Room - Brown Exterior Door / Window Frame / Trim Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Dark Brown, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 5.8%			
2022.619.001-15A 15	223063257-29 **Location:** 1st Fl., East Gym, Exterior Wall - Gray Column Cap Grout	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-15B 15	223063257-30 **Location:** 1st Fl., East Gym, Exterior Wall - Gray Column Cap Grout	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-16A 16	223063257-31 **Location:** 1st Fl., East Gym, Exterior Wall - Gray Column Cap Mortar	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Lt. Gray, Homogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-16B 16	223063257-32 **Location:** 1st Fl., East Gym, Exterior Wall - Gray Column Cap Mortar	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Lt. Gray, Homogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-17A 17	223063257-33 **Location:** 1st Fl., Between Sidewalk And East Gym Building - Black Expansion Joint Material	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Black, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 11.8%			
2022.619.001-17B 17	223063257-34 **Location:** 1st Fl., Between Sidewalk And East Gym Building - Black Expansion Joint Material	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Black, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 15.3%			
2022.619.001-18A 18	223063257-35 **Location:** 1st Fl., East Gym Entrance - Gray Sidewalk Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 11.3%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-18B 18	223063257-36 **Location:** 1st Fl., East Gym Entrance - Gray Sidewalk Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 10.3%			
2022.619.001-19A 19	223063257-37 **Location:** 1st Fl., East Gym Building - Gray Lower Roof Soffit Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 14%			
2022.619.001-19B 19	223063257-38 **Location:** 1st Fl., East Gym Building - Gray Lower Roof Soffit Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 16%			
2022.619.001-20A 20	223063257-39 **Location:** 2nd Fl., Weight Room, East Gym Building - Gray Sheetrock	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Brown/Gray, Heterogeneous, Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose 20%, Fibrous glass 1%, Non-fibrous 79%			
2022.619.001-20B 20	223063257-40 **Location:** 2nd Fl., Weight Room, East Gym Building - Gray Sheetrock	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Brown/Gray, Heterogeneous, Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose 15%, Fibrous glass 1%, Non-fibrous 84%			
2022.619.001-21A 21	223063257-41 **Location:** 2nd Fl., Weight Room, East Gym Building - White Joint Compound	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: White, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			

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PLM Bulk Asbestos Report

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-21B 21	223063257-42 **Location:** 2nd Fl., Weight Room, East Gym Building - White Joint Compound	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: White, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-22A 22	223063257-43 **Location:** 2nd Fl., Weight Room, East Gym Building - White Cove Base Mastic From Black Cove Base	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: White, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-22B 22	223063257-44 **Location:** 2nd Fl., Weight Room, East Gym Building - White Cove Base Mastic From Black Cove Base	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: White, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 10.7%			
2022.619.001-23A 23	223063257-45 **Location:** 2nd Fl., Weight Room, East Gym Building - White FRP Panel Mastic	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: White/Tan, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 26.2%			
2022.619.001-23B 23	223063257-46 **Location:** 2nd Fl., Weight Room, East Gym Building - White FRP Panel Mastic	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: White/Beige, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 25.7%			
2022.619.001-24A 24	223063257-47 **Location:** 1st Fl., Men's Locker Room, East Gym Building - Gray Sheetrock	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Grey, Homogeneous, Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose 1%, Fibrous glass 1%, Non-fibrous 98%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-24B 24	223063257-48 **Location:** 1st Fl., Men's Locker Room, East Gym Building - Gray Sheetrock	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose 1%, Fibrous glass Trace, Non-fibrous 99%			
2022.619.001-25A 25	223063257-49 **Location:** 1st Fl., Men's Locker Room, East Gym Building - White Joint Compound	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: White, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-25B 25	223063257-50 **Location:** 1st Fl., Men's Locker Room, East Gym Building - White Joint Compound	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: White, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-26A 26	223063257-51 **Location:** 1st Fl., Men's Locker Room, East Gym Building - 2' x 2' Pinhole Ceiling Tile	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: White/Beige, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 36.3%			
2022.619.001-26B 26	223063257-52 **Location:** 1st Fl., Men's Locker Room, East Gym Building - 2' x 2' Pinhole Ceiling Tile	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: White, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 44.5%			
2022.619.001-27A 27	223063257-53 **Location:** 1st Fl., Men's Locker Room, East Gym Building - Gray 2' x 2' Ceramic Tile Grout	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-27B 27	223063257-54 **Location:** 1st Fl., Men's Locker Room, East Gym Building - Gray 2' x 2' Ceramic Tile Grout	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 06/23/23
Analyst Description: Gray, Homogeneous, Non-Fibrous, Cementitious, Bulk Material **Asbestos Types:** **Other Material:** Cellulose Trace, Non-fibrous 100%			
2022.619.001-28A 28	223063257-55 **Location:** 1st Fl., Men's Locker Room, East Gym Building - Blue Epoxy Flooring	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Gray/Blue, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 59.9%			
2022.619.001-28B 28	223063257-56 **Location:** 1st Fl., Men's Locker Room, East Gym Building - Blue Epoxy Flooring	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Gray/Blue, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 64%			
2022.619.001-29A 29	223063257-57 **Location:** 1st Fl., Men's Locker Room, East Gym Building - Gray Interior Window Frame Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Lt. Gray, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 20.4%			
2022.619.001-29B 29	223063257-58 **Location:** 1st Fl., Men's Locker Room, East Gym Building - Gray Interior Window Frame Caulk	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 06/23/23
Analyst Description: Lt. Gray, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 24%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

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Reporting Notes:

Analyzed by: Valeriu Voicu
Date: 6/23/2023

Reviewed by: Marik Peysakhov

*NAD/NSD =no asbestos detected; NA =not analyzed; NA/PS=not analyzed/positive stop, (SOF-V) = Sprayed On Fireproofing containing Vermiculite; (SM-V) = Surfacing Material containing Vermiculite; PLM Bulk Asbestos Analysis using Olympus, Model BH-2 Pol Scope, Microscope, Serial #: 229915, by Appd E to Subpt E, 40 CFR 763 quantified by either CVES or 400 pt ct as noted for each analysis (NVLAP 200546-0), ELAP PLM Method 198.1 for NY friable samples, which includes the identification and quantitation of vermiculite, or ELAP 198.6 for NOB samples, or EPA 400 pt ct by EPA 600-M4-82-020 (NY ELAP Lab 11480); Note:PLM is not consistently reliable in detecting asbestos in floor coverings and similar non-friable organically bound materials. NAD or Trace results by PLM are inconclusive, TEM is currently the only method that can be used to determine if this material can be considered or treated as non asbestos-containing in NY State (also see EPA Advisory for floor tile, FR 59,146,38970,8/1/94) National Institute of Standards and Technology Accreditation requirements mandate that this report must not be reproduced except in full without the approval of the lab.This PLM report relates ONLY to the items tested. RI Cert AAL-094, CT Cert PH-0186, Mass Cert AA000054, NJ Lab ID #NY031.

_____END OF REPORT_____

AmeriSci New York
117 EAST 30TH ST.
NEW YORK, NY 10016
TEL: (212) 679-8600 • FAX: (212) 679-3114

PLM Bulk Asbestos Report

Delta Engineers
Attn: Stephen Prislupsky
860 Hooper Road

Endwell, NY 13760

Date Received 09/01/23 **AmeriSci Job #** 223091027
Date Examined 09/05/23 **P.O. #**
ELAP # 11480 **Page** 1 **of** 4

RE: 2022.619.001; Binghamton University; Binghamton University East Gym Addition Roof - Limited Pre - Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-30A 30	223091027-01 **Location:** Ext - Black Roof Seam Sealant - Roof Edge - North	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Black, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 7.6%			
2022.619.001-30B 30	223091027-02 **Location:** Ext - Black Roof Seam Sealant - Roof Edge - North	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Black, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 13.6%			
2022.619.001-31A 31	223091027-03 **Location:** Ext - White Gypsum Board Under EPDM At Roof Edge Flashing - Northwest	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 09/05/23
Analyst Description: White/Gray, Heterogeneous, Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Fibrous glass 15%, Non-fibrous 85%			
2022.619.001-31B 31	223091027-04 **Location:** Ext - White Gypsum Board Under EPDM At Roof Edge Flashing - Northeast	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 09/05/23
Analyst Description: White/Gray, Heterogeneous, Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Fibrous glass 20%, Non-fibrous 80%			
2022.619.001-32A 32	223091027-05 **Location:** Ext - Tan Adhesive From ISO Board Paper At Roof Edge Flashing - Northwest	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Tan, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 4.1%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; Binghamton University
East Gym Addition Roof - Limited Pre - Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-32B	223091027-06	***No***	NAD
32	**Location:** Ext - Tan Adhesive From ISO Board Paper At Roof Edge Flashing - Northeast		(by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Tan, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 4.5%			
2022.619.001-33A	223091027-07	***No***	NAD
33	**Location:** Ext - Black Vapor Barrier Under ISO Board At Roof Edge Flashing - Northwest		(by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Black, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 0.8%			
2022.619.001-33B	223091027-08	***No***	NAD
33	**Location:** Ext - Black Vapor Barrier Under ISO Board At Roof Edge Flashing - Northeast		(by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Black, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 1.8%			
2022.619.001-34A	223091027-09	***No***	NAD
34	**Location:** Ext - Black Hot Mop Under Vapor Barrier At Roof Edge Flashing - Northwest		(by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Black, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 1.4%			
2022.619.001-34B	223091027-10	***No***	NAD
34	**Location:** Ext - Black Hot Mop Under Vapor Barrier At Roof Edge Flashing - Northwest		(by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Black, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 0.7%			
2022.619.001-35A	223091027-11	***No***	NAD
35	**Location:** Ext - White Gypsum Board Under EPDM - Main Field - Northwest		(by NYS ELAP 198.1) by Valeriu Voicu on 09/05/23
Analyst Description: White/Tan, Heterogeneous, Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Fibrous glass 15%, Non-fibrous 85%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; Binghamton University
East Gym Addition Roof - Limited Pre - Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-35B 35	223091027-12 **Location:** Ext - White Gypsum Board Under EPDM - Main Field - Northeast	***No***	NAD (by NYS ELAP 198.1) by Valeriu Voicu on 09/05/23
Analyst Description: White, Heterogeneous, Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Fibrous glass 15%, Non-fibrous 85%			
2022.619.001-36A 36	223091027-13 **Location:** Ext - Tan Adhesive From ISO Board Paper - Main Field - Northwest	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Tan, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 4.6%			
2022.619.001-36B 36	223091027-14 **Location:** Ext - Tan Adhesive From ISO Board Paper - Main Field - Northeast	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Tan, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 6.5%			
2022.619.001-37A 37	223091027-15 **Location:** Ext - Black Vapor Barrier Under ISO Board - Main Field - Northwest	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Black, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 0.9%			
2022.619.001-37B 37	223091027-16 **Location:** Ext - Black Vapor Barrier Under ISO Board - Main Field - Northwest	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Black, Heterogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 1.8%			
2022.619.001-38A 38	223091027-17 **Location:** Ext - Black Hot Mop Under Vapor Barrier - Main Field - Northwest	***No***	NAD (by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23
Analyst Description: Black, Homogeneous, Non-Fibrous, Bulk Material **Asbestos Types:** **Other Material:** Non-fibrous 12.9%			

See Reporting notes on last page

PLM Bulk Asbestos Report

2022.619.001; Binghamton University; Binghamton University
East Gym Addition Roof - Limited Pre - Renovation Asbestos Survey

Client No. / HGA	Lab No.	Asbestos Present	Total % Asbestos
2022.619.001-38B	223091027-18	***No***	NAD
38	**Location:** Ext - Black Hot Mop Under Vapor Barrier - Main Field - Northwest		(by NYS ELAP 198.6) by Valeriu Voicu on 09/05/23

Analyst Description: Black, Homogeneous, Non-Fibrous, Bulk Material
Asbestos Types:
Other Material: Non-fibrous 5.2%

Reporting Notes:

Analyzed by: Valeriu Voicu
Date: 9/5/2023

Reviewed by: Feyza Gungor

*NAD/NSD =no asbestos detected; NA =not analyzed; NA/PS=not analyzed/positive stop, (SOF-V) = Sprayed On Fireproofing containing Vermiculite; (SM-V) = Surfacing Material containing Vermiculite; PLM Bulk Asbestos Analysis using Olympus, Model BH-2 Pol Scope, Microscope, Serial #: 229915, by Appd E to Subpt E, 40 CFR 763 quantified by either CVES or 400 pt ct as noted for each analysis (NVLAP 200546-0), ELAP PLM Method 198.1 for NY friable samples, which includes the identification and quantitation of vermiculite, or ELAP 198.6 for NOB samples, or EPA 400 pt ct by EPA 600-M4-82-020 (NY ELAP Lab 11480); Note:PLM is not consistently reliable in detecting asbestos in floor coverings and similar non-friable organically bound materials. NAD or Trace results by PLM are inconclusive, TEM is currently the only method that can be used to determine if this material can be considered or treated as non asbestos-containing in NY State (also see EPA Advisory for floor tile, FR 59,146,38970,8/1/94) National Institute of Standards and Technology Accreditation requirements mandate that this report must not be reproduced except in full without the approval of the lab.This PLM report relates ONLY to the items tested. RI Cert AAL-094, CT Cert PH-0186, Mass Cert AA000054, NJ Lab ID #NY031.

_____END OF REPORT_____

Table I
Summary of Bulk Asbestos Analysis Results

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

AmeriSci Sample #	Client Sample#	HG Area	Sample Weight (gram)	Heat Sensitive Organic %	Acid Soluble Inorganic %	Insoluble Non-Asbestos Inorganic %	** Asbestos % by PLM/DS	** Asbestos % by TEM
01	2022.619.001-01A	01	0.167	69.1	13.2	17.7	NAD	NAD
Location: 1st Fl., Exterior Bathroom - Gray Ext. Expansion Joint Caulk								
02	2022.619.001-01B	01	0.151	68.9	12.8	18.4	NAD	NAD
Location: 1st Fl., Exterior Bathroom - Gray Ext. Expansion Joint Caulk								
03	2022.619.001-02A	02	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Men's Room - Gray Ceramic Floor Tile Grout From Blue 2" x 2"								
04	2022.619.001-02B	02	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Men's Room - Gray Ceramic Floor Tile Grout From Blue 2" x 2"								
05	2022.619.001-03A	03	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Men's Room - Gray Ceramic Floor Tile Mortar / Adhesive From Blue 2" x 2"								
06	2022.619.001-03B	03	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Men's Room - Gray Ceramic Floor Tile Mortar / Adhesive From Blue 2" x 2"								
07	2022.619.001-04A	04	0.225	84.5	3.6	11.9	NAD	NAD
Location: 1st Fl., Exterior Men's Room - White Sink / Counter Caulk								
08	2022.619.001-04B	04	0.173	86.4	9.9	3.8	NAD	NAD
Location: 1st Fl., Exterior Ladies Room - White Sink / Counter Caulk								
09	2022.619.001-05A	05	0.290	64.5	25.6	9.8	NAD	NAD
Location: 1st Fl., Exterior Bathroom, Mechanical Room - Tan Ductwork Seam Caulk								
10	2022.619.001-05B	05	0.312	62.8	26.8	10.4	NAD	NAD
Location: 1st Fl., Exterior Bathroom, Mechanical Room - Tan Ductwork Seam Caulk								
11	2022.619.001-06A	06	0.248	47.0	35.6	17.4	NAD	NAD
Location: 1st Fl., Exterior Bathroom, Mechanical Room - White Fiberglass End Cap Mastic								
12	2022.619.001-06B	06	0.196	48.4	35.0	16.6	NAD	NAD
Location: 1st Fl., Exterior Bathroom, Mechanical Room - White Fiberglass End Cap Mastic								
13	2022.619.001-07A	07	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Men's Room - Ceiling Sheetrock								
14	2022.619.001-07B	07	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Ladies Room - Ceiling Sheetrock								
15	2022.619.001-08A	08	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Men's Room - Joint Compound From Ceiling Sheetrock								
16	2022.619.001-08B	08	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Ladies Room - Joint Compound From Ceiling Sheetrock								

See Reporting notes on last page

Table I
Summary of Bulk Asbestos Analysis Results

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

AmeriSci Sample #	Client Sample#	HG Area	Sample Weight (gram)	Heat Sensitive Organic %	Acid Soluble Inorganic %	Insoluble Non-Asbestos Inorganic %	** Asbestos % by PLM/DS	** Asbestos % by TEM
17	2022.619.001-09A	09	0.218	74.0	11.4	14.6	NAD	NAD
Location: 1st Fl., Exterior Men's Room - Counter Backsplash Adhesive								
18	2022.619.001-09B	09	0.247	76.0	10.5	13.5	NAD	NAD
Location: 1st Fl., Exterior Ladies Room - Counter Backsplash Adhesive								
19	2022.619.001-10A	10	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Ladies Room - Green Ceramic Floor Tile Mortar / Adhesive From Pink 2" x 2"								
20	2022.619.001-10B	10	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Ladies Room - Green Ceramic Floor Tile Mortar / Adhesive From Pink 2" x 2"								
21	2022.619.001-11A	11	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Ladies Room - Gray Ceramic Floor Tile Grout From Pink 2" x 2"								
22	2022.619.001-11B	11	----	----	----	----	NAD	NA
Location: 1st Fl., Exterior Ladies Room - Gray Ceramic Floor Tile Grout From Pink 2" x 2"								
23	2022.619.001-12A	12	0.241	69.7	24.5	5.8	NAD	NAD
Location: 1st Fl., Exterior Men's Room - Brown Interior Window Frame / Trim Caulk								
24	2022.619.001-12B	12	0.268	68.4	25.0	6.7	NAD	NAD
Location: 1st Fl., Exterior Ladies Room - Brown Interior Window Frame / Trim Caulk								
25	2022.619.001-13A	13	0.165	67.5	21.5	11.0	NAD	NAD
Location: 1st Fl., Exterior Bathroom Mechanical Room - Gray Perimeter Floor Slab Caulk								
26	2022.619.001-13B	13	0.169	68.4	19.4	12.2	NAD	NAD
Location: 1st Fl., Exterior Bathroom Mechanical Room - Gray Perimeter Floor Slab Caulk								
27	2022.619.001-14A	14	0.258	61.7	29.0	9.3	NAD	NAD
Location: 1st Fl., Exterior Men's Room - Brown Exterior Door / Window Frame / Trim Caulk								
28	2022.619.001-14B	14	0.224	74.0	20.2	5.8	NAD	NAD
Location: 1st Fl., Exterior Ladies Room - Brown Exterior Door / Window Frame / Trim Caulk								
29	2022.619.001-15A	15	----	----	----	----	NAD	NA
Location: 1st Fl., East Gym, Exterior Wall - Gray Column Cap Grout								
30	2022.619.001-15B	15	----	----	----	----	NAD	NA
Location: 1st Fl., East Gym, Exterior Wall - Gray Column Cap Grout								
31	2022.619.001-16A	16	----	----	----	----	NAD	NA
Location: 1st Fl., East Gym, Exterior Wall - Gray Column Cap Mortar								
32	2022.619.001-16B	16	----	----	----	----	NAD	NA
Location: 1st Fl., East Gym, Exterior Wall - Gray Column Cap Mortar								

See Reporting notes on last page

Table I
Summary of Bulk Asbestos Analysis Results

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

AmeriSci Sample #	Client Sample#	HG Area	Sample Weight (gram)	Heat Sensitive Organic %	Acid Soluble Inorganic %	Insoluble Non-Asbestos Inorganic %	** Asbestos % by PLM/DS	** Asbestos % by TEM
33	2022.619.001-17A	17	0.551	81.9	6.2	11.8	NAD	NAD
Location: 1st Fl., Between Sidewalk And East Gym Building - Black Expansion Joint Material								
34	2022.619.001-17B	17	0.340	76.2	8.5	15.3	NAD	NAD
Location: 1st Fl., Between Sidewalk And East Gym Building - Black Expansion Joint Material								
35	2022.619.001-18A	18	0.195	67.8	20.9	11.3	NAD	NAD
Location: 1st Fl., East Gym Entrance - Gray Sidewalk Caulk								
36	2022.619.001-18B	18	0.205	69.6	20.1	10.3	NAD	NAD
Location: 1st Fl., East Gym Entrance - Gray Sidewalk Caulk								
37	2022.619.001-19A	19	0.174	63.5	22.5	14.0	NAD	NAD
Location: 1st Fl., East Gym Building - Gray Lower Roof Soffit Caulk								
38	2022.619.001-19B	19	0.198	69.8	14.2	16.0	NAD	NAD
Location: 1st Fl., East Gym Building - Gray Lower Roof Soffit Caulk								
39	2022.619.001-20A	20	----	----	----	----	NAD	NA
Location: 2nd Fl., Weight Room, East Gym Building - Gray Sheetrock								
40	2022.619.001-20B	20	----	----	----	----	NAD	NA
Location: 2nd Fl., Weight Room, East Gym Building - Gray Sheetrock								
41	2022.619.001-21A	21	----	----	----	----	NAD	NA
Location: 2nd Fl., Weight Room, East Gym Building - White Joint Compound								
42	2022.619.001-21B	21	----	----	----	----	NAD	NA
Location: 2nd Fl., Weight Room, East Gym Building - White Joint Compound								
43	2022.619.001-22A	22	0.310	26.3	65.2	8.5	NAD	NAD
Location: 2nd Fl., Weight Room, East Gym Building - White Cove Base Mastic From Black Cove Base								
44	2022.619.001-22B	22	0.248	20.5	68.8	10.7	NAD	NAD
Location: 2nd Fl., Weight Room, East Gym Building - White Cove Base Mastic From Black Cove Base								
45	2022.619.001-23A	23	0.169	62.1	11.7	26.2	NAD	NAD
Location: 2nd Fl., Weight Room, East Gym Building - White FRP Panel Mastic								
46	2022.619.001-23B	23	0.233	60.2	14.1	25.7	NAD	NAD
Location: 2nd Fl., Weight Room, East Gym Building - White FRP Panel Mastic								
47	2022.619.001-24A	24	----	----	----	----	NAD	NA
Location: 1st Fl., Men's Locker Room, East Gym Building - Gray Sheetrock								
48	2022.619.001-24B	24	----	----	----	----	NAD	NA
Location: 1st Fl., Men's Locker Room, East Gym Building - Gray Sheetrock								

See Reporting notes on last page

Table I
Summary of Bulk Asbestos Analysis Results

2022.619.001; Binghamton University; East Gym Addition And Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey

AmeriSci Sample #	Client Sample#	HG Area	Sample Weight (gram)	Heat Sensitive Organic %	Acid Soluble Inorganic %	Insoluble Non-Asbestos Inorganic %	** Asbestos % by PLM/DS	** Asbestos % by TEM
49	2022.619.001-25A	25	----	----	----	----	NAD	NA
Location: 1st Fl., Men's Locker Room, East Gym Building - White Joint Compound								
50	2022.619.001-25B	25	----	----	----	----	NAD	NA
Location: 1st Fl., Men's Locker Room, East Gym Building - White Joint Compound								
51	2022.619.001-26A	26	0.171	13.1	50.6	36.3	NAD	NAD
Location: 1st Fl., Men's Locker Room, East Gym Building - 2' x 2' Pinhole Ceiling Tile								
52	2022.619.001-26B	26	0.113	19.4	36.1	44.5	NAD	NAD
Location: 1st Fl., Men's Locker Room, East Gym Building - 2' x 2' Pinhole Ceiling Tile								
53	2022.619.001-27A	27	----	----	----	----	NAD	NA
Location: 1st Fl., Men's Locker Room, East Gym Building - Gray 2' x 2' Ceramic Tile Grout								
54	2022.619.001-27B	27	----	----	----	----	NAD	NA
Location: 1st Fl., Men's Locker Room, East Gym Building - Gray 2' x 2' Ceramic Tile Grout								
55	2022.619.001-28A	28	0.245	18.7	21.3	59.9	NAD	NAD
Location: 1st Fl., Men's Locker Room, East Gym Building - Blue Epoxy Flooring								
56	2022.619.001-28B	28	0.214	19.2	16.8	64.0	NAD	NAD
Location: 1st Fl., Men's Locker Room, East Gym Building - Blue Epoxy Flooring								
57	2022.619.001-29A	29	0.171	33.7	45.9	20.4	NAD	NAD
Location: 1st Fl., Men's Locker Room, East Gym Building - Gray Interior Window Frame Caulk								
58	2022.619.001-29B	29	0.201	32.7	43.3	24.0	NAD	NAD
Location: 1st Fl., Men's Locker Room, East Gym Building - Gray Interior Window Frame Caulk								

Analyzed by: Marik Peysakhov

Date: 6/23/2023

Reviewed by: Marik Peysakhov

**Quantitative Analysis (Semi/Full); Bulk Asbestos Analysis - PLM by Appd E to Subpt E, 40 CFR 763 or NYSDOH ELAP 198.1 for New York friable samples or NYSDOH ELAP 198.6 for New York NOB samples; TEM (Semi/Full) by EPA 600/R-93/116 (or NYSDOH ELAP 198.4; for New York samples). Analysis using Hitachi, Model H7000-Noran 7 System, Microscope, Serial #: 747-05-06. NAD = no asbestos detected during a quantitative analysis; NA = not analyzed; Trace = <1%; (SOF-V) = Sprayed On Fireproofing containing Vermiculite; (SM-V) = Surfacing Material containing Vermiculite; Quantitation for beginning weights of <0.1 grams should be considered as qualitative only; Qualitative Analysis: Asbestos analysis results of "Present" or "NVA = No Visible Asbestos" represents results for Qualitative PLM or TEM Analysis only (no accreditation coverage available from any regulatory agency for qualitative analyses): NVLAP (PLM) 200546-0, NYSDOH ELAP Lab 11480, NJ Lab ID #NY031.

Warning Note: PLM limitation, only TEM will resolve fibers <0.25 micrometers in diameter. TEM bulk analysis is representative of the fine grained matrix material and may not be representative of non-uniformly dispersed debris for which PLM evaluation is recommended (i.e. soils and other heterogenous materials).

Table I
Summary of Bulk Asbestos Analysis Results

2022.619.001; Binghamton University; Binghamton University East Gym Addition Roof - Limited Pre - Renovation Asbestos Survey

AmeriSci Sample #	Client Sample#	HG Area	Sample Weight (gram)	Heat Sensitive Organic %	Acid Soluble Inorganic %	Insoluble Non-Asbestos Inorganic %	** Asbestos % by PLM/DS	** Asbestos % by TEM
01	2022.619.001-30A	30	0.369	54.9	37.4	7.6	NAD	NAD
Location: Ext - Black Roof Seam Sealant - Roof Edge - North								
02	2022.619.001-30B	30	0.257	55.4	31.1	13.6	NAD	NAD
Location: Ext - Black Roof Seam Sealant - Roof Edge - North								
03	2022.619.001-31A	31	----	----	----	----	NAD	NA
Location: Ext - White Gypsum Board Under EPDM At Roof Edge Flashing - Northwest								
04	2022.619.001-31B	31	----	----	----	----	NAD	NA
Location: Ext - White Gypsum Board Under EPDM At Roof Edge Flashing - Northeast								
05	2022.619.001-32A	32	0.143	61.0	34.8	4.1	NAD	NAD
Location: Ext - Tan Adhesive From ISO Board Paper At Roof Edge Flashing - Northwest								
06	2022.619.001-32B	32	0.131	93.7	1.8	4.5	NAD	NAD
Location: Ext - Tan Adhesive From ISO Board Paper At Roof Edge Flashing - Northeast								
07	2022.619.001-33A	33	0.424	89.5	9.7	0.8	NAD	NAD
Location: Ext - Black Vapor Barrier Under ISO Board At Roof Edge Flashing - Northwest								
08	2022.619.001-33B	33	0.473	86.5	11.7	1.8	NAD	NAD
Location: Ext - Black Vapor Barrier Under ISO Board At Roof Edge Flashing - Northeast								
09	2022.619.001-34A	34	0.655	95.2	3.4	1.4	NAD	NAD
Location: Ext - Black Hot Mop Under Vapor Barrier At Roof Edge Flashing - Northwest								
10	2022.619.001-34B	34	0.375	97.5	1.8	0.7	NAD	NAD
Location: Ext - Black Hot Mop Under Vapor Barrier At Roof Edge Flashing - Northwest								
11	2022.619.001-35A	35	----	----	----	----	NAD	NA
Location: Ext - White Gypsum Board Under EPDM - Main Field - Northwest								
12	2022.619.001-35B	35	----	----	----	----	NAD	NA
Location: Ext - White Gypsum Board Under EPDM - Main Field - Northeast								
13	2022.619.001-36A	36	0.237	92.3	3.0	4.6	NAD	NAD
Location: Ext - Tan Adhesive From ISO Board Paper - Main Field - Northwest								
14	2022.619.001-36B	36	0.241	91.5	2.0	6.5	NAD	NAD
Location: Ext - Tan Adhesive From ISO Board Paper - Main Field - Northeast								
15	2022.619.001-37A	37	0.301	89.5	9.6	0.9	NAD	NAD
Location: Ext - Black Vapor Barrier Under ISO Board - Main Field - Northwest								
16	2022.619.001-37B	37	0.307	88.7	9.6	1.8	NAD	NAD
Location: Ext - Black Vapor Barrier Under ISO Board - Main Field - Northwest								

See Reporting notes on last page

Client Name: Delta Engineers

Table I
Summary of Bulk Asbestos Analysis Results

2022.619.001; Binghamton University; Binghamton University East Gym Addition Roof - Limited Pre - Renovation Asbestos Survey

AmeriSci Sample #	Client Sample#	HG Area	Sample Weight (gram)	Heat Sensitive Organic %	Acid Soluble Inorganic %	Insoluble Non-Asbestos Inorganic %	** Asbestos % by PLM/DS	** Asbestos % by TEM
17	2022.619.001-38A	38	0.263	75.5	11.6	12.9	NAD	NAD
Location:	Ext - Black Hot Mop Under Vapor Barrier - Main Field - Northwest							
18	2022.619.001-38B	38	0.202	88.0	6.7	5.2	NAD	NAD
Location:	Ext - Black Hot Mop Under Vapor Barrier - Main Field - Northwest							

Analyzed by: Feyza Gungor

Date: 9/5/2023

Reviewed by: Feyza Gungor

**Quantitative Analysis (Semi/Full); Bulk Asbestos Analysis - PLM by Appd E to Subpt E, 40 CFR 763 or NYSDOH ELAP 198.1 for New York friable samples or NYSDOH ELAP 198.6 for New York NOB samples; TEM (Semi/Full) by EPA 600/R-93/116 (or NYSDOH ELAP 198.4; for New York samples). Analysis using Hitachi, Model H7000-Noran 7 System, Microscope, Serial #: 747-05-06. NAD = no asbestos detected during a quantitative analysis; NA = not analyzed; Trace = <1%; (SOF-V) = Sprayed On Fireproofing containing Vermiculite; (SM-V) = Surfacing Material containing Vermiculite; Quantitation for beginning weights of <0.1 grams should be considered as qualitative only; Qualitative Analysis: Asbestos analysis results of "Present" or "NVA = No Visible Asbestos" represents results for Qualitative PLM or TEM Analysis only (no accreditation coverage available from any regulatory agency for qualitative analyses): NVLAP (PLM) 200546-0, NYSDOH ELAP Lab 11480, NJ Lab ID #NY031.

Warning Note: PLM limitation, only TEM will resolve fibers <0.25 micrometers in diameter. TEM bulk analysis is representative of the fine grained matrix material and may not be representative of non-uniformly dispersed debris for which PLM evaluation is recommended (i.e. soils and other heterogenous materials).

DELTA
ENGINEERS, ARCHITECTS, & SURVEYORS

860 Hooper Road, Endwell, NY 13760 Tel:607.231.6600 Fax:607.231.6640
www.delta-eas.com

Bulk Sample Data Sheet / COC

Client:	Binghamton University	**Delta Project No.:**	2022.619.001	**Date:**	6/21/2023
Project:	East Gym Addition and Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey	**Client Project No.:**		**Turnaround Time:**	**48 Hour**
		Collected By:	William Johnson/Greg Umbra		

Sample Number		Material Type	Material Condition	Floor	Description / Sample Location
2022.619.001 -	01A	Miscellaneous	Intact	1	Gray Exterior Expansion Joint Caulk - Exterior Bathroom
2022.619.001 -	01B	Miscellaneous	Intact	1	Gray Exterior Expansion Joint Caulk - Exterior Bathroom
2022.619.001 -	02A	Miscellaneous	Intact	1	Gray Ceramic Floor Tile Grout from Blue 2"x2" - Exterior Men's Room
2022.619.001 -	02B	Miscellaneous	Intact	1	Gray Ceramic Floor Tile Grout from Blue 2"x2" - Exterior Men's Room
2022.619.001 -	03A	Miscellaneous	Intact	1	Gray Ceramic Floor Tile Mortar/Adhesive from Blue 2"x2" - Exterior Men's Room
2022.619.001 -	03B	Miscellaneous	Intact	1	Gray Ceramic Floor Tile Mortar/Adhesive from Blue 2"x2" - Exterior Men's Room
2022.619.001 -	04A	Miscellaneous	Intact	1	White Sink/Counter Caulk - Exterior Men's Room
2022.619.001 -	04B	Miscellaneous	Intact	1	White Sink/Counter Caulk - Exterior Ladies Room
2022.619.001 -	05A	Miscellaneous	Intact	1	Tan Ductwork Seam Caulk - Exterior Bathroom Mechanical Room

Instructions: Analyze all non-NOB samples by NYS ELAP 198.1 PLM methodology. Analyze all NOB samples initially by NYS ELAP 198.6 PLM methodology. If all samples from a given sample set are reported as non-asbestos by 198.6, analyze by NYS ELAP 198.4 TEM methodology. Stop analysis after 1st positive for a given sample set.

Email results to wjohnson@delta-eas.com, sprislupsky@delta-eas.com, rcherevko@delta-eas.com

Notes: 223063257

Submitted By: William Johnson / _____ **Date:** 6/21/2023
(Printed) (Signature)

Received By: T Liang / T Liang **Date:** 6/22/23 10:47
(Printed) (Signature)

DELTA
ENGINEERS, ARCHITECTS, & SURVEYORS

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Bulk Sample Data Sheet / COC

Client:	Binghamton University	**Delta Project No.:**	2022.619.001	**Date:**	6/21/2023
Project:	East Gym Addition and Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey	**Client Project No.:**		**Turnaround Time:**	**48 Hour**
		Collected By:	William Johnson/Greg Umbra		223063257

Sample Number		Material Type	Material Condition	Floor	Description / Sample Location
2022.619.001 -	05B	Miscellaneous	Intact	1	Tan Ductwork Seam Caulk - Exterior Bathroom Mechanical Room
2022.619.001 -	06A	Miscellaneous	Intact	1	White Fiberglass End Cap Mastic - Exterior Bathroom Mechanical Room
2022.619.001 -	06B	Miscellaneous	Intact	1	White Fiberglass End Cap Mastic - Exterior Bathroom Mechanical Room
2022.619.001 -	07A	Miscellaneous	Intact	1	Sheetrock Ceiling - Exterior Men's Room
2022.619.001 -	07B	Miscellaneous	Intact	1	Sheetrock Ceiling - Exterior Ladies Room
2022.619.001 -	08A	Miscellaneous	Intact	1	Joint Compound from Sheetrock Ceiling - Exterior Men's Room
2022.619.001 -	08B	Miscellaneous	Intact	1	Joint Compound from Sheetrock Ceiling - Exterior Ladies Room
2022.619.001 -	09A	Miscellaneous	Intact	1	Counter Back Splash Adhesive - Exterior Men's Room
2022.619.001 -	09B	Miscellaneous	Intact	1	Counter Back Splash Adhesive - Exterior Ladies Room
2022.619.001 -	10A	Miscellaneous	Intact	1	Green Ceramic Floor Tile Mortar/Adhesive from Pink 2"x2" - Exterior Ladies Room
2022.619.001 -	10B	Miscellaneous	Intact	1	Green Ceramic Floor Tile Mortar/Adhesive from Pink 2"x2" - Exterior Ladies Room
2022.619.001 -	11A	Miscellaneous	Intact	1	Gray Ceramic Floor Tile Grout from Pink 2"x2" - Exterior Ladies Room
2022.619.001 -	11B	Miscellaneous	Intact	1	Gray Ceramic Floor Tile Grout from Pink 2"x2" - Exterior Ladies Room
2022.619.001 -	12A	Miscellaneous	Intact	1	Brown Interior Window Frame/Trim Caulk - Exterior Men's Room
2022.619.001 -	12B	Miscellaneous	Intact	1	Brown Interior Window Frame/Trim Caulk - Exterior Ladies Room
2022.619.001 -	13A	Miscellaneous	Intact	1	Gray Perimeter Floor Slab Caulk - Exterior Bathroom Mechanical Room

DELTA
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Bulk Sample Data Sheet / COC

Client:	Binghamton University	**Delta Project No.:**	2022.619.001	**Date:**	6/21/2023
Project:	East Gym Addition and Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey	**Client Project No.:**		**Turnaround Time:**	48 Hour
		Collected By:	William Johnson/Greg Umbra		22306 3257

Sample Number		Material Type	Material Condition	Floor	Description / Sample Location
2022.619.001 -	13B	Miscellaneous	Intact	1	Gray Perimeter Floor Slab Caulk - Exterior Bathroom Mechanical Room
2022.619.001 -	14A	Miscellaneous	Intact	1	Brown Exterior Door/Window Frame/Trim Caulk - Exterior Men's Room
2022.619.001 -	14B	Miscellaneous	Intact	1	Brown Exterior Door/Window Frame/Trim Caulk - Exterior Ladies Room
2022.619.001 -	15A	Miscellaneous	Intact	1	Gray Column Cap Grout - East Gym Exterior Wall
2022.619.001 -	15B	Miscellaneous	Intact	1	Gray Column Cap Grout - East Gym Exterior Wall
2022.619.001 -	16A	Miscellaneous	Intact	1	Gray Column Cap Mortar - East Gym Exterior Wall
2022.619.001 -	16B	Miscellaneous	Intact	1	Gray Column Cap Mortar - East Gym Exterior Wall
2022.619.001 -	17A	Miscellaneous	Intact	1	Black Expansion Joint Material - Between Sidewalk and East Gym Building
2022.619.001 -	17B	Miscellaneous	Intact	1	Black Expansion Joint Material - Between Sidewalk and East Gym Building
2022.619.001 -	18A	Miscellaneous	Intact	1	Gray Sidewalk Caulk - East Gym Entrance
2022.619.001 -	18B	Miscellaneous	Intact	1	Gray Sidewalk Caulk - East Gym Entrance
2022.619.001 -	19A	Miscellaneous	Intact	1	Gray Lower Roof Soffit Caulk - East Gym Building
2022.619.001 -	19B	Miscellaneous	Intact	1	Gray Lower Roof Soffit Caulk - East Gym Building
2022.619.001 -	20A	Miscellaneous	Intact	2	Gray Sheetrock - 2nd Floor Weight Room East Gym Building
2022.619.001 -	20B	Miscellaneous	Intact	2	Gray Sheetrock - 2nd Floor Weight Room East Gym Building
2022.619.001 -	21A	Miscellaneous	Intact	2	White Joint Compound - 2nd Floor Weight Room East Gym Building

DELTA
ENGINEERS, ARCHITECTS, & SURVEYORS

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Bulk Sample Data Sheet / COC

Client:	Binghamton University	**Delta Project No.:**	2022.619.001	**Date:**	6/21/2023
Project:	East Gym Addition and Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey	**Client Project No.:**		**Turnaround Time:**	**48 Hour**
		Collected By:	William Johnson/Greg Umbra		223063257

Sample Number		Material Type	Material Condition	Floor	Description / Sample Location
2022.619.001 -	21B	Miscellaneous	Intact	2	White Joint Compound - 2nd Floor Weight Room East Gym Building
2022.619.001 -	22A	Miscellaneous	Intact	2	White Cove Base Mastic from Black Cove Base -2nd Floor Weight Room East Gym Building
2022.619.001 -	22B	Miscellaneous	Intact	2	White Cove Base Mastic from Black Cove Base -2nd Floor Weight Room East Gym Building
2022.619.001 -	23A	Miscellaneous	Intact	2	White FRP Panel Mastic - 2nd Floor Weight Room East Gym Building
2022.619.001 -	23B	Miscellaneous	Intact	2	White FRP Panel Mastic - 2nd Floor Weight Room East Gym Building
2022.619.001 -	24A	Miscellaneous	Intact	1	Gray Sheetrock - Men's Locker Room East Gym Building
2022.619.001 -	24B	Miscellaneous	Intact	1	Gray Sheetrock - Men's Locker Room East Gym Building
2022.619.001 -	25A	Miscellaneous	Intact	1	White Joint Compound - Men's Locker Room East Gym Building
2022.619.001 -	25B	Miscellaneous	Intact	1	White Joint Compound - Men's Locker Room East Gym Building
2022.619.001 -	26A	Miscellaneous	Intact	1	2'x2' Pin Hole Ceiling Tile - Men's Locker Room East Gym Building
2022.619.001 -	26B	Miscellaneous	Intact	1	2'x2' Pin Hole Ceiling Tile - Men's Locker Room East Gym Building
2022.619.001 -	27A	Miscellaneous	Intact	1	Gray 2'x2' Ceramic Tile Grout - Men's Locker Room East Gym Building
2022.619.001 -	27B	Miscellaneous	Intact	1	Gray 2'x2' Ceramic Tile Grout - Men's Locker Room East Gym Building
2022.619.001 -	28A	Miscellaneous	Intact	1	Blue Epoxy Flooring - Men's Locker Room East Gym Building
2022.619.001 -	28B	Miscellaneous	Intact	1	Blue Epoxy Flooring - Men's Locker Room East Gym Building
2022.619.001 -	29A	Miscellaneous	Intact	1	Gray Interior Window Frame Caulk - Men's Locker Room East Gym Building

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Bulk Sample Data Sheet / COC

Client:	Binghamton University	**Delta Project No.:**	2022.619.001	**Date:**	6/21/2023
Project:	East Gym Addition and Exterior Bathroom, Vestal, NY - Limited Pre-Renovation Asbestos Survey	**Client Project No.:**		**Turnaround Time:**	**48 Hour**
		Collected By:	William Johnson/Greg Umbra		223063257

Sample Number		Material Type	Material Condition	Floor	Description / Sample Location
2022.619.001 -	29B	Miscellaneous	Intact	1	Gray Interior Window Frame Caulk - Men's Locker Room East Gym Building

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Bulk Sample Data Sheet / COC

2230901027

Client: Binghamton University	**Delta Project No.:** 2022.619.001	**Date:** 8/31/2023
Project: Binghamton University East Gym Addition Roof - Limited Pre-Renovation Asbestos Survey	**Client Project No.:**	**Turnaround Time:** 4 day
	Collected By: Greg Umbra	

Sample Number		Material Type	Material Condition	Floor	Description / Sample Location
2022.619.001 -	30A	Miscellaneous	Intact	Ext	Black Roof Seam Sealant - Roof Edge - North
2022.619.001 -	30B	Miscellaneous	Intact	Ext	Black Roof Seam Sealant - Roof Edge - North
2022.619.001 -	31A	Miscellaneous	Intact	Ext	White Gypsum Board Under EPDM At Roof Edge Flashing - Northwest
2022.619.001 -	31B	Miscellaneous	Intact	Ext	White Gypsum Board Under EPDM At Roof Edge Flashing - Northeast
2022.619.001 -	32A	Miscellaneous	Intact	Ext	Tan Adhesive From ISO Board Paper At Roof Edge Flashing - Northwest
2022.619.001 -	32B	Miscellaneous	Intact	Ext	Tan Adhesive From ISO Board Paper At Roof Edge Flashing - Northeast
2022.619.001 -	33A	Miscellaneous	Intact	Ext	Black Vapor Barrier Under ISO Bloard At Roof Edge Flashing - Northwest
2022.619.001 -	33B	Miscellaneous	Intact	Ext	Black Vapor Barrier Under ISO Bloard At Roof Edge Flashing - Northeast

Instructions: Analyze all non-NOB samples by NYS ELAP 198.1 PLM methodology. Analyze all NOB samples initially by NYS ELAP 198.6 PLM methodology. If all samples from a given sample set are reported as non-asbestos by 198.6, analyze by NYS ELAP 198.4 TEM methodology. Stop analysis after 1st positive for a given sample set.

Email results to wjohnson@delta-eas.com, sprislupsky@delta-eas.com, rcherevko@delta-eas.com

Notes: _____

Submitted By: Greg Umbra / [signature] **Date:** 8/31/2023
(Printed) (Signature)

Received By: Efrain Nunez / [signature] **Date:** 9/1/23 1045
(Printed) (Signature)

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223091027

Bulk Sample Data Sheet / COC

Client:	Binghamton University	**Delta Project No.:**	2022.619.001	**Date:**	8/31/2023
Project:	Binghamton University East Gym Addition Roof - Limited Pre-Renovation Asbestos Survey	**Client Project No.:**		**Turnaround Time:**	**4 day**
		Collected By:	Greg Umbra		

Sample Number		Material Type	Material Condition	Floor	Description / Sample Location
2022.619.001 -	34A	Miscellaneous	Intact	Ext	Black Hot Mop Under Vapor Barrier At Roof Edge Flashing - Northwast
2022.619.001 -	34B	Miscellaneous	Intact	Ext	Black Hot Mop Under Vapor Barrier At Roof Edge Flashing - Northwast
2022.619.001 -	35A	Miscellaneous	Intact	Ext	White Gypsum Board Under EPDM - Main Field - Northwest
2022.619.001 -	35B	Miscellaneous	Intact	Ext	White Gypsum Board Under EPDM - Main Field - Northeast
2022.619.001 -	36A	Miscellaneous	Intact	Ext	Tan Adhesive From ISO Board Paper - Main Field - Northwest
2022.619.001 -	36B	Miscellaneous	Intact	Ext	Tan Adhesive From ISO Board Paper - Main Field - Northeast
2022.619.001 -	37A	Miscellaneous	Intact	Ext	Black Vapor Barrier Under ISO Bloard - Main Field - Northwest
2022.619.001 -	37B	Miscellaneous	Intact	Ext	Black Vapor Barrier Under ISO Bloard - Main Field - Northwest
2022.619.001 -	38A	Miscellaneous	Intact	Ext	Black Hot Mop Under Vapor Barrier - Main Field - Northwast
2022.619.001 -	38B	Miscellaneous	Intact	Ext	Black Hot Mop Under Vapor Barrier - Main Field - Northwast

ENGINEERS, ARCHITECTS, & SURVEYORS

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Fax 607.231.6650
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APPENDIX C

Delta Engineers, Architects, & Land Surveyors
Company and Personnel Certifications

WE ARE YOUR DOL

NEW YORK STATE | Department of Labor

DIVISION OF SAFETY & HEALTH LICENSE AND CERTIFICATE UNIT, STATE OFFICE CAMPUS, BLDG. 12, ALBANY, NY 12226

ASBESTOS HANDLING LICENSE

Delta Engineers, Architects, Land Surveyors, & Landscape, Architects, D.P.C.
860 Hooper Road, Endwell, NY, 13760

License Number: 29322
License Class: RESTRICTED
Date of Issue: 09/29/2022
Expiration Date: 10/31/2023
Duly Authorized Representative: Stephen Prislupsky

This license has been issued in accordance with applicable provisions of Article 30 of the Labor Law of New York State and of the New York State Codes, Rules and Regulations (12 NYCRR Part 56). It is subject to suspension or revocation for a (1) serious violation of state, federal or local laws with regard to the conduct of an asbestos project, or (2) demonstrated lack of responsibility in the conduct of any job involving asbestos or asbestos material.

This license is valid only for the contractor named above and this license or a photocopy must be prominently displayed at the asbestos project worksite. This license verifies that all persons employed by the licensee on an asbestos project in New York State have been issued an Asbestos Certificate, appropriate for the type of work they perform, by the New York State Department of Labor.

Amy Phillips, Director
For the Commissioner of Labor

STATE OF NEW YORK - DEPARTMENT OF LABOR
ASBESTOS CERTIFICATE

N.Y.S

WILLIAM T JOHNSON
CLASS(EXPIRES)
C ATEC(11/23) D INSP(11/23)
H PM (11/23) I PD (11/23)

CERT# 88-05722
DMV# 183706373

MUST BE CARRIED ON ASBESTOS PROJECTS

01213 0065902297 35

EYES HAZ
HAIR BRO
HGT 5' 10"

IF FOUND RETURN TO:
NYSDOL - L&C UNIT
ROOM 161A BUILDING 12
STATE OFFICE CAMPUS
ALBANY NY 12240

STATE OF NEW YORK - DEPARTMENT OF LABOR
ASBESTOS CERTIFICATE

N.Y.S

GREGORY D UMBRA
CLASS(EXPIRES)
C ATEC(01/24) D INSP(01/24)
H PM (01/24)

CERT# 93-08135
SMV# 358658422

MUST BE CARRIED ON ASBESTOS PROJECTS

01213 006603718 55

EYES BRO
HAIR BRO
HGT 6' 00"

IF FOUND RETURN TO:
NYSDOL - L&C UNIT
ROOM 161A BUILDING 12
STATE OFFICE CAMPUS
ALBANY NY 12240

ENGINEERS, ARCHITECTS, & SURVEYORS

860 Hooper Road,
Endwell, NY 13760
Tel: 607.231.6600
Fax 607.231.6650
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APPENDIX D

Laboratory Certifications

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

Expires 12:01 AM April 01, 2024
Issued April 01, 2022
Revised March 30, 2023

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MS. KAROL H. LU
AMERICA SCIENCE TEAM NEW YORK, INC
117 EAST 30TH ST
NEW YORK, NY 10016

NY Lab Id No: 11480

is hereby APPROVED as an Environmental Laboratory for the category
ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE
All approved subcategories and/or analytes are listed below:

Miscellaneous

Asbestos in Friable Material	Item 198.1 of Manual
	EPA 600/M4/82/020
Asbestos in Non-Friable Material-PLM	Item 198.6 of Manual (NOB by PLM)
Asbestos in Non-Friable Material-TEM	Item 198.4 of Manual

Serial No.: 66402

ENGINEERS, ARCHITECTS, & SURVEYORS

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Fax 607.231.6650
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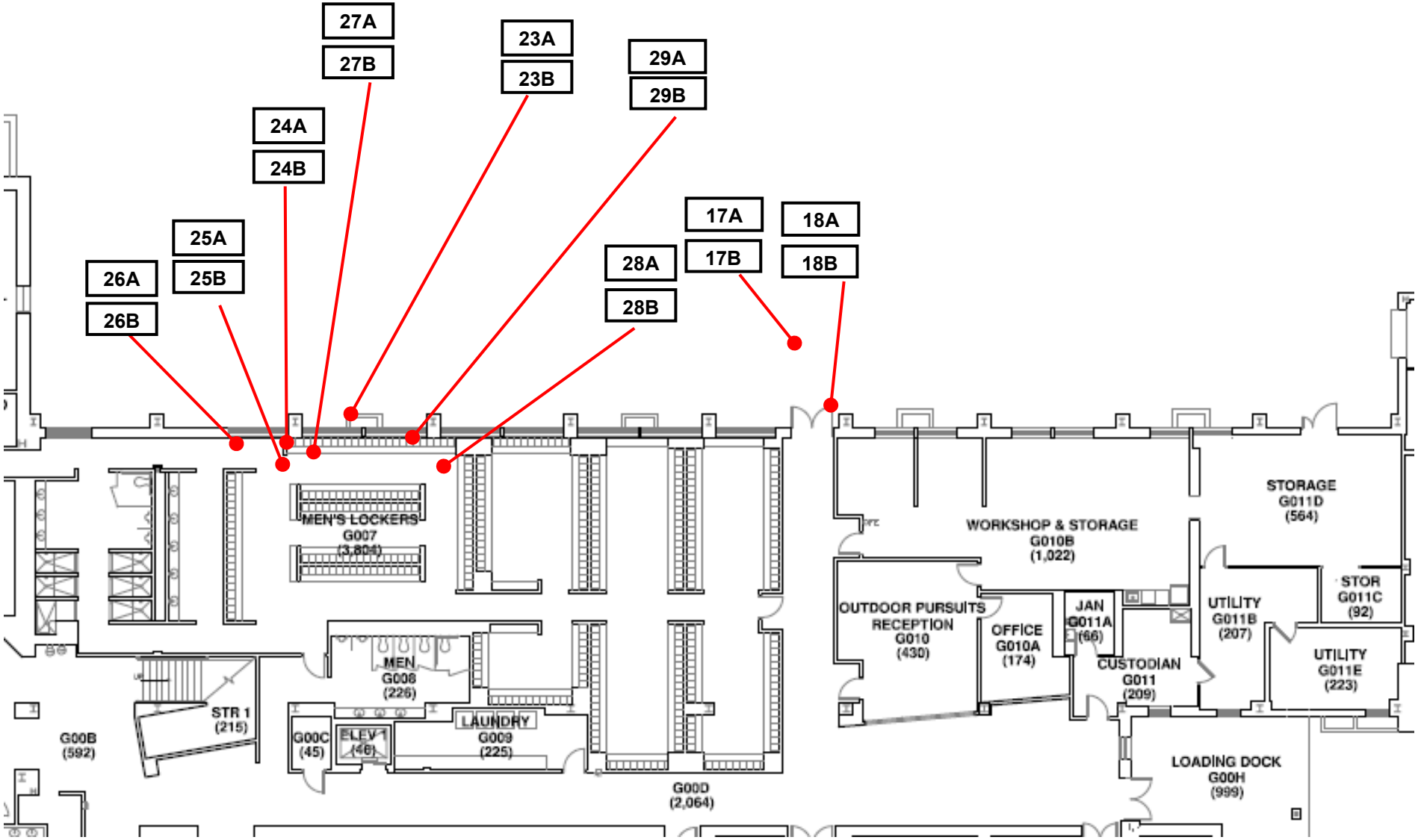
APPENDIX E

Sample Location Drawings



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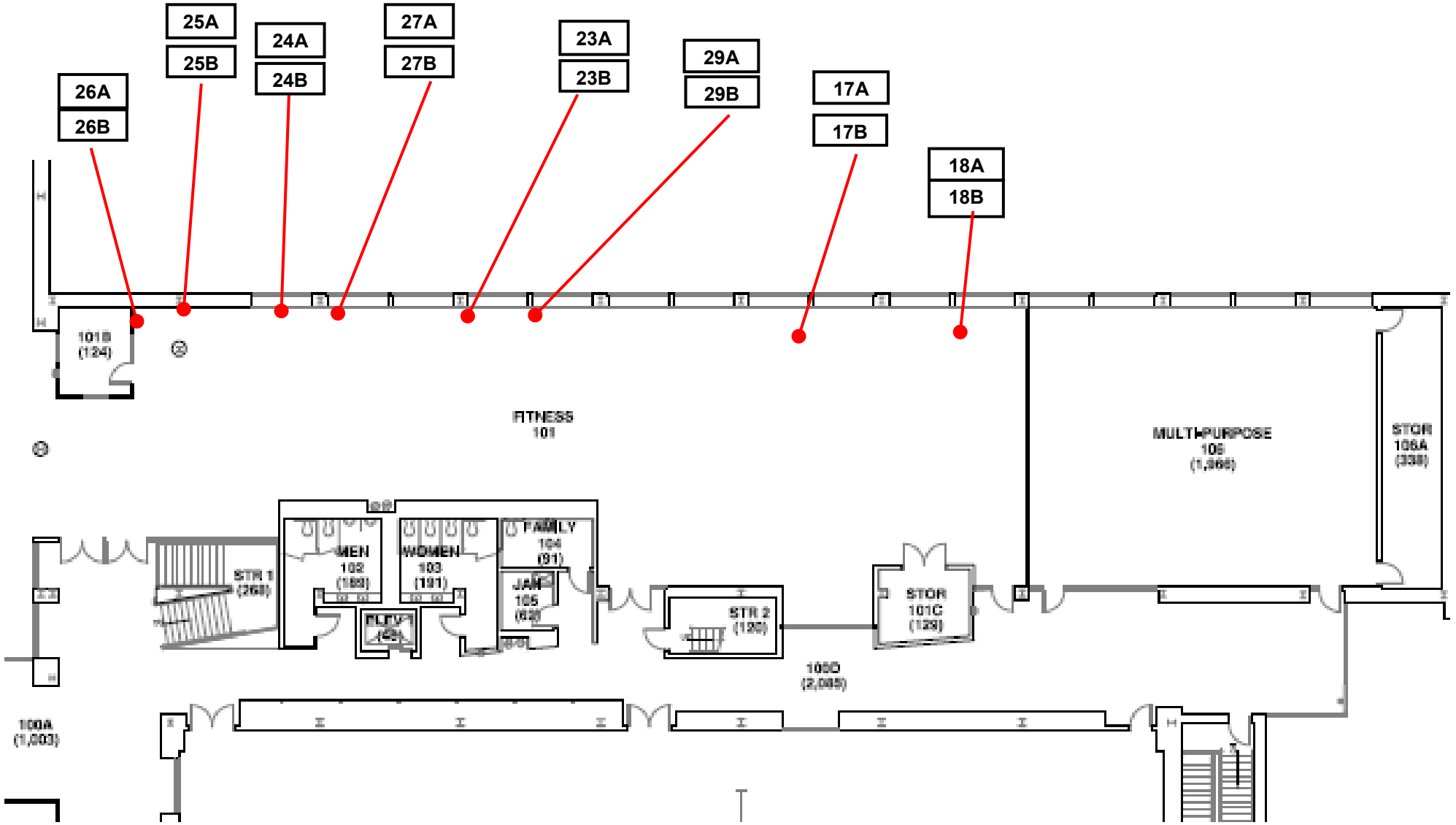
Delta Project No.: 2022.619.001	**Project Name:** .Eat Gym Pre-Renovation Survey	
Work Area: Ground Floor and Exterior	**Sample Type:** Asbestos Bulk Samples	
Client: Binghamton University	**Bldg. No.:** N/A	**Page:** 1 **of** 1
Date(s) Sampled: 06/21/2023	**Drawn By:** G. Umbra	**Scale:** NTS



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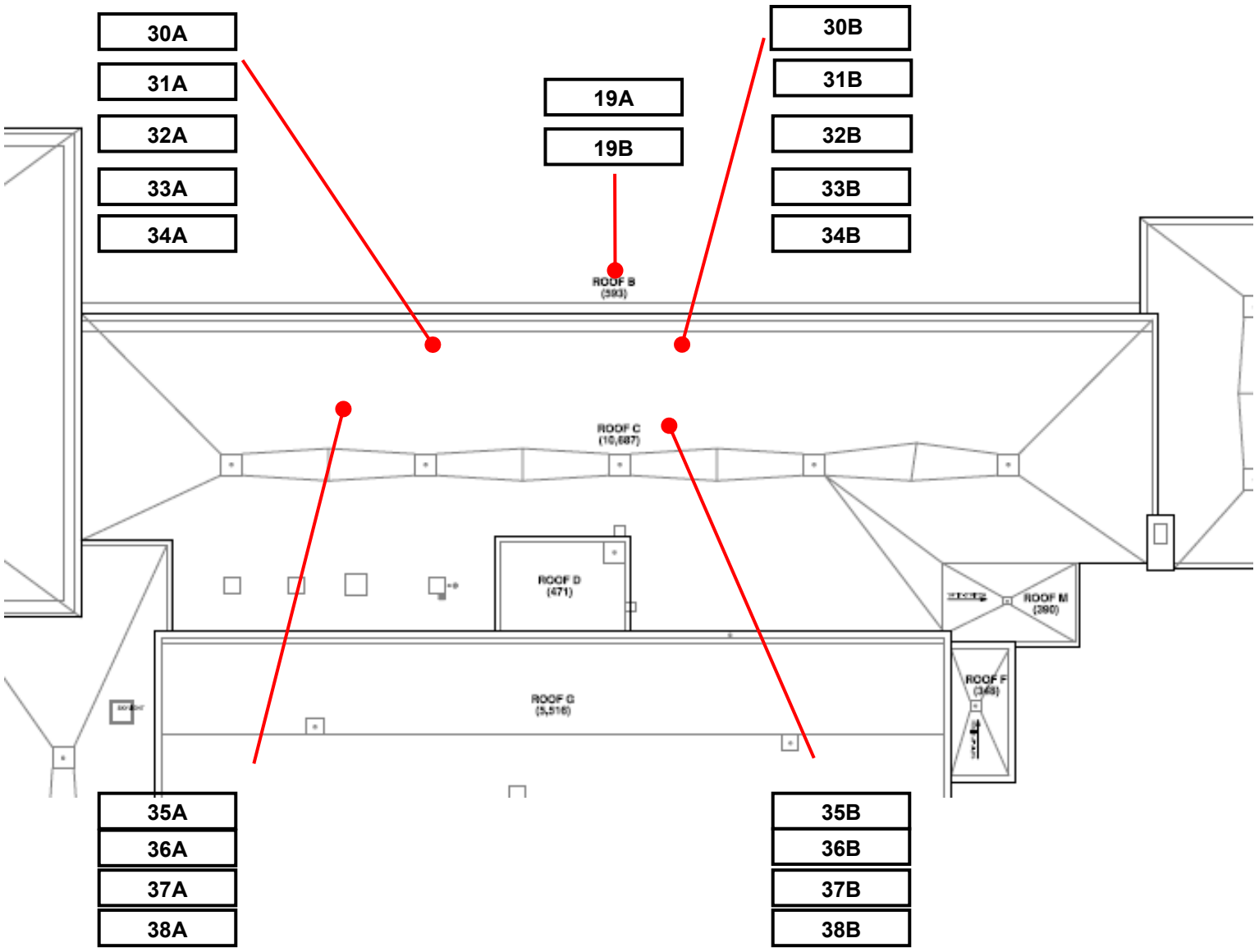
860 Hooper Road, Endwell, NY 13760
Tel: 607.231.6600 : Fax: 607.231.6651
www.delta-eas.com

Delta Project No.: 2022.619.001	**Project Name:** .Eat Gym Pre-Renovation Survey	
Work Area: 1st Floor	**Sample Type:** Asbestos Bulk Samples	
Client: Binghamton University	**Bldg. No.:** N/A	**Page:** 1 **of** 1
Date(s) Sampled: 06/21/2023	**Drawn By:** G. Umbra	**Scale:** NTS



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Tel: 607.231.6600 : Fax: 607.231.6651
www.delta-eas.com

Delta Project No.: 2022.619.001	**Project Name:** .Eat Gym Pre-Renovation Survey	
Work Area: Roof	**Sample Type:** Asbestos Bulk Samples	
Client: Binghamton University	**Bldg. No.:** N/A	**Page:** 1 **of** 1
Date(s) Sampled: 08/31/2023	**Drawn By:** G. Umbra	**Scale:** NTS

Kenney Geotechnical Services

Kenney Geotechnical Engineering Services PLLC

Geotechnical Evaluation Report

East Gym Addition
Binghamton University
Binghamton, New York

C.M. KENNEY PE
2-16-2023

CONTENTS

INTRODUCTION

This report presents the results of the geotechnical investigation performed for the proposed East Gym Addition on the Binghamton University campus in Binghamton, New York. This geotechnical report presents the data developed during the subsurface investigation and provides analysis and recommendations for the proposed construction.

No environmental services are included in this study. No conclusions have been drawn regarding environmental conditions of the site, potential contaminants, potential special treatment or disposal of site materials, or other environmental considerations.

AUTHORIZATION

The scope of our services for this project was presented in a proposal dated October 31, 2022. Our services were authorized by Delta Engineers, Architects, Land Surveyors & Landscape Architects, DPC (Delta).

PROJECT DESCRIPTION

It is our understanding that the proposed project will include a 50,000 square foot (sf) addition to the north side of the existing gymnasium. There will be 25,000 sf of elevated floor space, and the roof will have a long span structure. The following figure illustrates the proposed project area:

DESIGN CRITERIA

Structural loads were not available at the time of this report. We have assumed a tolerable total settlement of up to one inch.

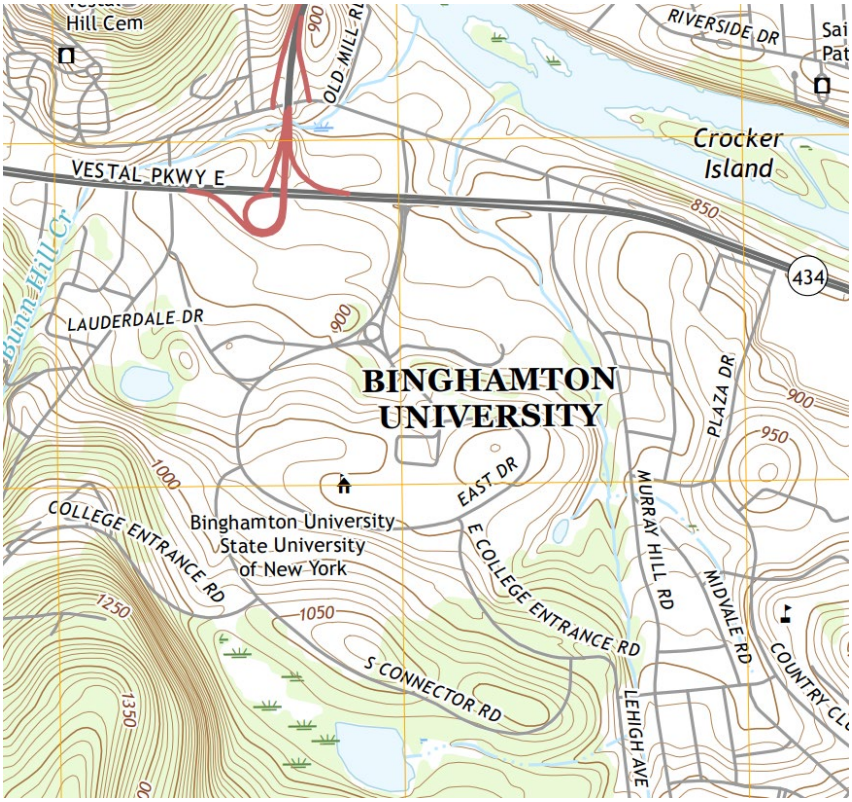
The following ASTM Standards were utilized during this study:

- ASTM D1586 "Penetration Test and Split-Barrel Sampling of Soils"
- ASTM D2487 "Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)"
- ASTM D5434 "Standard Guide for Field Logging of Subsurface Exploration of Soil and Rock"

Local geotechnical practice was followed in the performance of this study. Frost depth was assumed to be 48 inches.

SITE CONDITIONS

The proposed project area generally consisted of hardscaping and lawn area adjacent to the existing gymnasium. Area topography is illustrated in the following figure excerpted from USGS mapping:



Site topography is illustrated in the following figure provided by Delta:

INFORMATION PROVIDED FOR THIS STUDY

Delta provided the following information for this study:

- Base Requirements Scope Guidelines
- Project Specific Requirements
- East Gym Boring Map
- East Gym – Site Model

AREA GEOMORPHOLOGY AND SURFICIAL GEOLOGY

The site is located within the Susquehanna River Valley, which cuts through the Allegheny Plateau in a west-east orientation in the Town of Vestal. The site is located approximately 1500 feet south of the Susquehanna River. The area was last glaciated approximately 16,000 years ago, and glacial drift deposits of Pleistocene age are located above bedrock in most locations. The glacial drift includes valley-fill deposits and till. Till is typically the dominant deposit in upland areas and may be

present in the valleys. Valley-fill includes fluvial, deltaic, and lacustrine origin deposits of silt, sand and gravel and can be up to 300 feet in thickness.

The valley-fill was typically deposited during deglaciation, and deposits of outwash sand and gravel are common in the valley. Holocene deposits include alluvium and peat/muck deposits. The peat and muck deposits formed in areas of poor drainage, including in kettleholes in pitted-outwash areas. A typical valley cross-section is ;

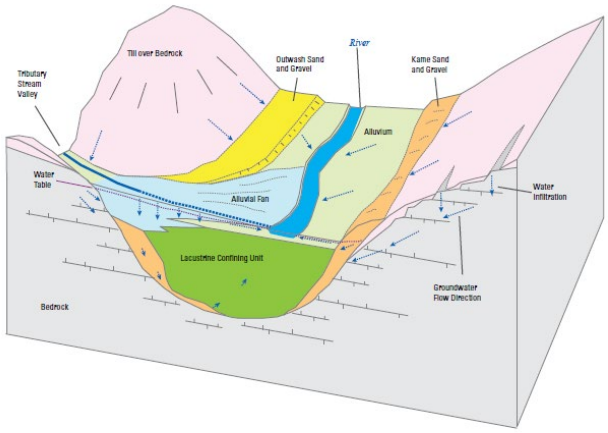


Figure 10. Conceptual block diagram of groundwater flow in the Susquehanna valley-fill aquifer system.

Bedrock mapping suggests that West Falls Group shale and siltstone underlies soil in the area.

PRE-DEVELOPMENT SITE CONDITIONS

A review of publically available mapping and aerial photography did not indicate any substantial site development prior to campus construction.

FIELD STUDY

The subsurface investigation for this project consisted of ten test borings (designated as B-1 to B-10), two infiltration tests (IT-1 and IT-2) and the installation of a temporary piezometer. The test borings were performed using a track-mounted Geoprobe 3126GT drill rig. The borings were advanced to depths of up to 30 feet below the ground surface (bgs). Standard penetration testing (ASTM D1586) was performed with an automatic hammer to obtain soil samples. Boring locations were field-located by Kenney Geotechnical Services personnel after private utilities were identified.

Soil samples obtained during the subsurface investigation were classified by a Geotechnical Engineer using the Unified Soil Classification System. Boring logs documenting the subsurface conditions encountered are attached. The boring logs and related information depict subsurface conditions only at the specific locations and times indicated. Subsurface conditions and water levels at other locations may differ from conditions at the locations where sampling was conducted. The passage of time also may result in changes in the conditions interpreted to exist at the locations where sampling was performed.

LABORATORY TESTING

Laboratory testing performed for this project included Natural Moisture Content Testing (ASTM D-2216) and Particle Size Analysis (ASTM D-422). Testing was performed in Kenney Geotechnical Services laboratory. Test results are attached to this report.

SUBSURFACE CONDITIONS ENCOUNTERED

The following interpretation of subsurface conditions is based on our review of the recovered samples, the boring logs, drilling observations, and our professional experience.

The subsurface conditions encountered generally consisted of a fill layer overlying outwash gravel. Glacial till was encountered below the outwash gravel at some of the boring locations. A layer of topsoil approximately six inches in thickness was encountered at the ground surface.

The fill generally consisted of gravel and sand mixed with silt and clay with some construction debris. It appears the fill was placed to level the field during earthwork for campus construction. Fill was encountered to depths of approximately two to eight feet across the site, with the depth of fill generally increasing to the north and east. The fill was generally medium dense, with Standard Penetration Testing (SPT) "N" values ranging from 5 to 50 blows per foot (bpf). A layer of buried organic laden soil approximately two feet in thickness was encountered below the fill at boring locations B-1 and B-4.

The outwash gravel deposit extended from the base of the fill to depths of 20 feet to more than 30 feet. The outwash gravel deposit generally consisted of medium dense to dense silty gravel with sand. A few lenses of stiff silty clay were encountered

within the outwash gravel. Cobbles and possible boulders were present throughout the deposit. SPT N values ranged from 5 to 100 bpf and averaged 32 bpf.

Glacial till was encountered below the outwash gravel deposit at boring locations B-3, B-4, B-5, and B-8. The glacial till was encountered at depths ranging from 20 feet to 28 feet and consisted of dense grey silty clayey gravel with sand.

GROUNDWATER CONDITIONS ENCOUNTERED

Water levels were measured within the augers during advancement and from the open borehole after the augers were removed. The following table summarizes the water level measurements at the time of the subsurface investigation.

Boring Location	Depth to Water While Advancing Augers (feet)	Depth to Water at End of Drilling (ft)	Depth to Water After Augers Removed (ft)	Depth to Borehole Cave-In (ft)
B-1	18.0	18.9	DRY	15.0
B-2	18.0	21.3	17.1	19.5
B-3	18.0	26.2	DRY	18.1
B-4	18.0	19.7	DRY	16.4
B-5	15.5	23.8	15.1	16.2
B-6	DRY	DRY	DRY	9.8
B-7	18.0	25.9	N/A	16.4
B-8	DRY	25.6	DRY	20.5
B-9	DRY	DRY	DRY	15.0
B-10	13.0	10.4	8.5	22.7

Groundwater depths and seepage rates will vary with the seasons and changes in precipitation patterns and may be higher during the wetter seasons.

INFILTRATION TESTING

Infiltration testing was performed in accordance with NYSDEC guidelines at two locations designated by Delta adjacent to boring B-3 and B-8, respectively. The infiltration testing was performed at a depth of 8 feet as directed by Delta. Infiltration testing results are as follows:

Location	Depth (ft)	Soil	Stabilized Infiltration Rate (inches/hour)
B-3	8	GWS	6
B-8	8	GM	3

RECOMMENDATIONS AND CONCLUSIONS

The glacial outwash deposit is a suitable bearing layer for the proposed addition. The fill layer should be removed from below foundation bearing grade and replaced with approved structural fill. The fill layer may be suitable for support of a slab-on-grade provided the topsoil is stripped and proof-rolling is performed as recommended under Earthwork.

A. Foundations

An allowable bearing pressure of 3,500 pounds per square foot (psf) is recommended for the design of shallow foundations provided that the bearing grade consists of undisturbed natural medium dense to dense gravel as verified by geotechnical personnel. Any uncontrolled fill, disturbed or saturated soil must be removed from below foundation bearing grade as directed by geotechnical personnel. Excavations resulting from the removal of unsuitable material must be backfilled with compacted structural fill as approved by geotechnical personnel.

Proper management of the soil will be critical during foundation construction and earthwork. All exterior footings should bear at least 48 inches below finished exterior grade for frost protection unless an insulated frost protection system is installed. Foundation bearing grade must be protected from saturation, freezing, or disturbance throughout construction.

We estimate that foundations designed as recommended herein and properly managed during construction will undergo total settlements of less than one inch and differential settlements of up to 0.75 inches.

B. Temporary Excavations

Temporary excavation slopes must be evaluated by the Contractor's on-site Responsible Person. We anticipate on-site soil will be classified as Type C. Type C materials must be graded to slopes no greater than 1.5:1 (horizontal to vertical).

The site soils will not remain stable if excavated vertically. Shoring should be utilized to prevent loss of ground below existing structures if new excavations in close proximity are planned. The Contractors on-site Responsible Person should periodically review excavations for signs of movement or distress. Excavation sidewalls should be periodically raked to remove loose particles.

C. Utility Trenches

In utility trenches, or other confined areas, small compaction equipment may be necessary such as a vibratory plate, jumping jack or walk-behind vibratory roller. In-place density testing should be performed at a frequency of one test per 25 feet per lift in trenches. Utility trench fill should be placed in level lifts no greater than 8 inches in thickness and should be compacted to at least 95%the Modified Proctor (ASTM D-1557) maximum dry density. Structural fill should consist of imported granular material such as NYSDOT Subbase (2" minus) or approved equal. Adequate frost cover and protection must be provided during winter weather construction. Earthwork cannot be performed with frozen material. On-site materials may be acceptable as use as structural fill pending field review by geotechnical personnel.

D. Earthwork

Earthwork must be performed using methods that will result in a stable excavations and fills. Typical temporary earthwork measures such as temporary drainage swales, stabilized haul roads, and the use of protective layers of crushed stone can be employed at this site. It is recommended that earthwork is observed by geotechnical personnel to ensure that all organic material is removed from the structural and pavement site. Additional recommendations are as follows:

- Strip existing topsoil, pavement, roots and organics as directed by geotechnical personnel from all areas that will receive new construction to establish subgrade.
- Proof-roll exposed slab-on-grade subgrade with a fully loaded dump truck, or accepted alternative equipment, under the observation of geotechnical personnel. Excessive organic matter and areas that rut, weave, or deflect should be over-excavated and replaced with compacted structural fill as directed by geotechnical personnel (see below for structural fill characteristic requirements).
- Utilize structural fill to raise site grades. Structural fill should consist of imported granular material conforming to NYSDOT Subbase Course (2"

minus) or approved equal. On-site materials may be acceptable as use as structural fill pending field review by geotechnical personnel.

- Field moisture contents for structural fill should be maintained within 2 percentage points of the optimum moisture content established by laboratory testing to provide adequate compaction. All fill should be placed in level lifts having a loose thickness no greater than 12 inches and should be compacted to at least the following minimum percentages of the Modified Proctor (ASTM D-1557) maximum dry density:

    - Below footings: 95%
    - Beneath slab-on-grade or pavements: 95%
    - Utility trench backfill: 95%
    - Beneath landscape areas: 90%
    - Beneath sidewalks and exterior slabs: 95%

    Bulk samples of proposed structural fill materials should be delivered to our testing laboratory at least two weeks prior to the initiation of earthwork. In-place density testing should be performed at a frequency of one test per 500 square feet per lift in open areas and one test per 25 feet per lift in trenches.
- If the structure is to be constructed during the winter months, or if the building interiors will be subjected to freezing temperatures after footer construction, adequate frost cover and protection must be provided. Earthwork cannot be performed with frozen material.
- Permanent slopes should be graded no steeper than 3 horizontal: 1 vertical.

E. Groundwater Seepage and Management

Groundwater was encountered at a depth of 16.4 feet in the temporary piezometer on February 16, 2023. Storm events and other factors can affect groundwater and seepage during construction. All dewatering discharge should be transported to a temporary dewatering basin constructed consistent with NYDEC construction stormwater and/or dewatering treatment Best Management Practices (BMPs).

F. Interior Concrete Slabs

Subgrade areas should be prepared as discussed in the Earthwork

recommendations. A preliminary subgrade modulus of 250 pci is suggested for design and assumes compacted structural fill is installed over stripped subgrade to achieve new floor slab elevations. Structural fill placed to establish floor slab subgrade should conform to the recommendations for materials and compaction presented in the Earthwork recommendations.

The subbase for the slab-on-grade should consist of a minimum of 6 inches of gravel or crushed stone conforming to NYSDOT specifications for Item 304-2.02 Type 2 or 4. Follow compaction requirements presented for earthwork.

G. Lateral Earth Pressures

Design of subsurface walls subjected to lateral earth pressure must consider the type of wall, degree of restraint against wall rotation, and other factors. The sliding resistance of soils should also be considered during excavation. The following lateral earth pressure parameters of an approved imported granular fill are recommended for this project. The following earth pressure and sliding parameters are recommended for the soil encountered on this project.

- Ka = 0.33
- Kp = 3.0
- Ko = 0.5
- Unit weight of imported soil 140 pcf
- Coefficient of sliding = 0.4

It is recommended that drainage is provided for all walls to reduce hydrostatic wall loading and possible frost action. Backfill against any walls should consist of a relatively well-graded free-draining granular material having no more than 10% passing the No. 200 sieve. The granular backfill zone behind walls should be at least one foot wide as measured horizontally from the face of the wall. Backfill against walls should be placed in loose lifts no greater than 6 inches in thickness. A nonwoven geotextile filter should be placed between the granular backfill and insitu soil to prevent the migration of fine-grained soil.

I. Seismic Hazard Concerns, Liquefaction, Seismicity, and Faulting

Correlations with Standard Penetration Testing "N" values recorded during the subsurface investigation suggest that seismic **Site Class D** is appropriate for this site. The estimated design spectral response acceleration parameters are as

follows:

Design Code Reference:	ASCE 7-16
Assumed Risk Category:	III
Site Class:	D
S_{DS}	0.122g
S_{D1}	0.072g
S_{MS}	0.183g
S_{M1}	0.108g

Liquefaction, surface rupture from faulting or lateral spreading is estimated to have a low probability of occurrence given typical regional seismicity.

J. Pavement Sections

The pavement sections recommended below are based on the assumption that the subgrade will be prepared as discussed in this report and that adequate drainage is maintained throughout construction. Recommended pavement sections are provided for medium duty (car parking) areas, heavy duty areas (main drive), and bus parking areas.

Medium Duty Pavement:

- 1.5 inches – Top Course
- 3.0 inches – Binder Course
- 12 inches – Subbase Course
- Woven Geotextile Layer (500X)

Heavy Duty Pavement:

- 1.5 inches – Top Course
- 3.5 inches – Binder Course
- 12 inches – Subbase Course
- Woven Geotextile Layer (500X)

Bus Parking Area Pavement:

- 1.5 inches – Top Course
- 4.5 inches – Binder Course
- 12 inches – Subbase Course
- Woven Geotextile Layer (500X)

Please note that the pavement sections provided above were designed primarily for automobile and bus traffic with occasional tractor-trailer traffic and are not intended for heavy construction vehicle traffic. Temporary construction traffic lanes may require a thicker subbase to provide a stable surface for heavy construction vehicles.

Exposed subgrades of proposed pavement areas should be evaluated by proof-rolling using a loaded tandem axle dump truck or a 10 ton smooth drum roller (static mode). Proof-rolling, evaluation of subgrades, and any undercutting and stabilization should be monitored by a qualified geotechnical engineer.

The materials for the recommended pavement sections should consist of the following:

- Asphalt Concrete Top Course - NYSDOT Standard Specifications, Item No. 402.128902 - Hot Mix Asphalt, Top Course.
- Asphalt Concrete Binder Course - NYSDOT Standard Spec., Item No. 402.198902 - Hot Mix Asphalt, Binder Course.
- Subbase Course – Should comply with NYSDOT Standard Specifications, Item No. 304.12 - Type 2 or Item No. 304.14 – Type 4 Subbase.
- Geotextile - Woven polypropylene stabilization/separation geotextile (i.e., Mirafi 500X or approved similar).

Adjacent geotextile panels should have an overlap of at least 18 inches. The subbase should be placed and compacted in accordance with the recommendations presented below. Construction of the asphaltic concrete courses (i.e. binder and top) should be performed in accordance with NYSDOT Standard Specification Section 400. Asphaltic concrete courses should be compacted to at least 92 percent of the maximum theoretical density. Subbase should be compacted to 95% of the Modified Proctor maximum theoretical density at a moisture content within two percent of the optimum moisture content.

LIMITATIONS

The recommendations presented in this report are predicated on the performance of construction observation and testing by qualified geotechnical personnel. We request continued involvement with this project so that we may assess subsurface conditions exposed during construction to determine if modifications to our recommendations are necessary. This report should not be considered as direction to the Contractor.

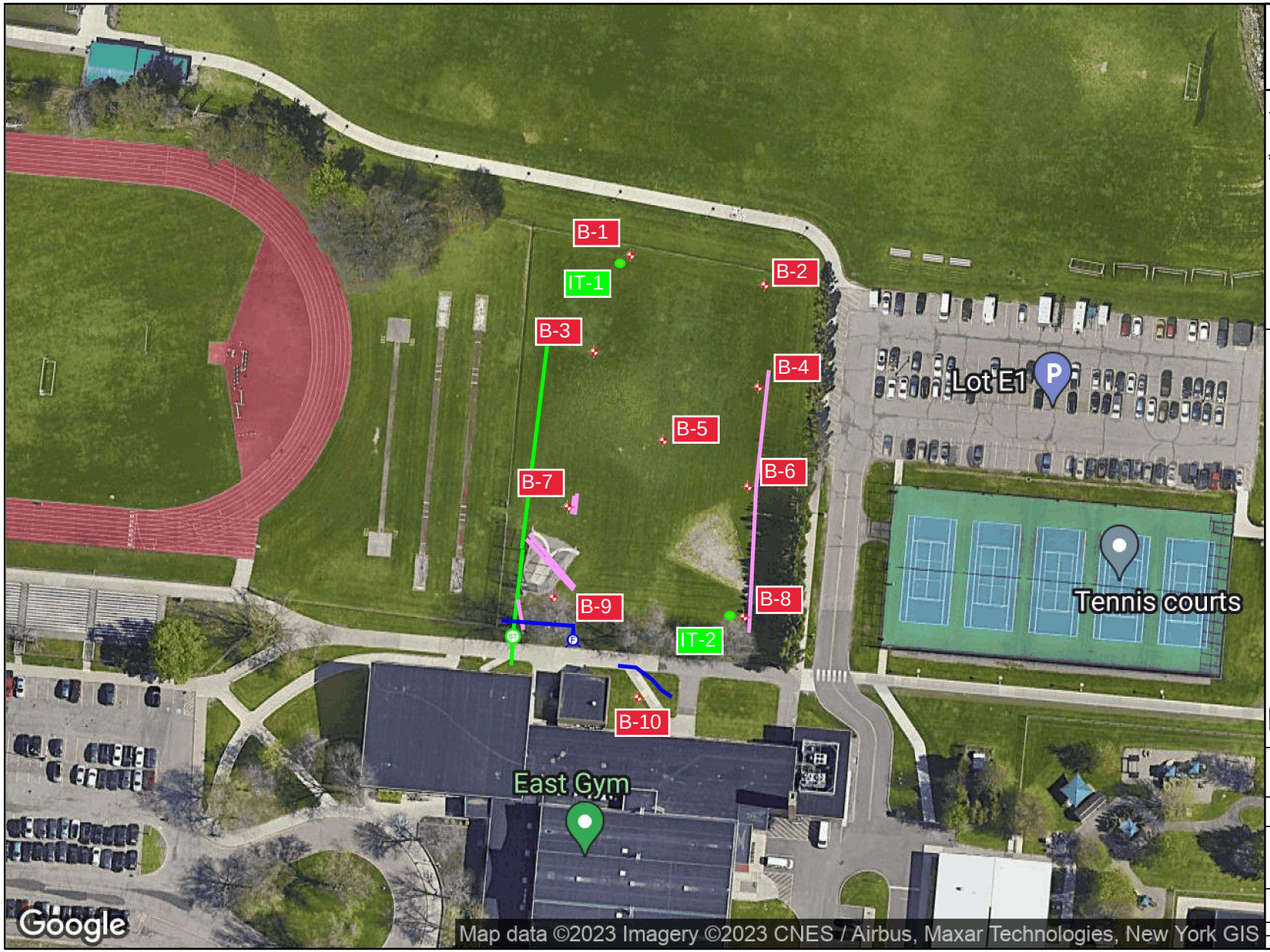
REFERENCES

"Surficial Geologic Map of New York –Finger Lakes Sheet", New York State Museum, 1986.

"Bedrock Map of New York – Finger Lakes Sheet", New York State Museum, 1970.

ATTACHMENTS

BORING LOGS



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LEGEND

- STORM
- UNKNOWN
- WATER

0' 25' 50' 75' 100'

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GPRS FINDINGS MAP

PREPARED FOR:
KENNEY GEOTECHNICAL SERVICES

LOCATION:
BINGHAMTON COLLEGE
4400 VESTAL PARKWAY E.
BINGHAMTON, NY

PROJECT MANAGER:
JOE GOODFELLOW
JOE.GOODFELLOW@GPRSINC.COM

DATE	2023 JAN 24		
DRAWING NO.	1	REV.	2

519224

- AIR_COMPRESSOR
- AIR_CONTINUES
- AIR_EOI
- AIR_MANHOLE
- AIR_MISC
- AIR_PUMP
- AIR_RISER
- CHEM_AST
- CHEM_CONTINUES
- CHEM_EOI
- CHEM_MANHOLE
- CHEM_MISC
- CHEM_PUMP
- CHEM_TANK
- CHEM_VALVE
- COMM_BOX
- COMM_CAMERA
- COMM_CONTINUES
- COMM_EOI
- COMM_MANHOLE
- COMM_MISC
- COMM_PEDESTAL
- COMM_POLE
- COMM_VAULT
- ELEC_BOX
- ELEC_CABINET
- ELEC_CONTINUES
- ELEC_EOI
- ELEC_EQUIPMENT
- ELEC_LANDSCAPELIGHT
- ELEC_MANHOLE
- ELEC_METER
- ELEC_MISC
- ELEC_PANEL
- ELEC_POWERPOLE
- ELEC_SIGN
- ELEC_SITELIGHT
- ELEC_TRANSFORMER
- ELEC_UTILITYPOLE
- ELEC_VAULT
- FIRE_BACKFLOWPREVENTOR
- FIRE_CONTINUES
- FIRE_EOI
- FIRE_HYDRANT
- FIRE_MANHOLE
- FIRE_METER
- FIRE_MISC
- FIRE_POSTINDICATORVALVE
- FIRE_RISER
- FIRE_VALVE
- FUEL_AST
- FUEL_CONTINUES
- FUEL_EOI
- FUEL_MANHOLE
- FUEL_MISC
- FUEL_PUMP
- FUEL_RISER
- FUEL_UST
- FUEL_VALVE
- FUEL_VAULT
- FUEL_VENT
- GAS_AST
- GAS_CONTINUES
- GAS_EOI
- GAS_MANHOLE
- GAS_METER
- GAS_MISC
- GAS_PUMP
- GAS_RISER
- GAS_UST
- GAS_VALVE
- GAS_VAULT
- GAS_VENT
- IRR_BACKFLOWPREVENTOR
- IRR_CONTINUES
- IRR_CONTROL VALVE
- IRR_EOI
- IRR_MISC
- IRR_RISER
- IRR_SPRINKLER
- MISC_CONTINUES
- MISC_DEPTH
- MISC_EOI
- MISC_MANHOLE
- MISC_POINT
- MISC_VALVE
- OIL_CONTINUES
- OIL_EOI
- OIL_MANHOLE
- OIL_MISC
- OIL_PUMP
- OIL_RISER
- OIL_TANK
- OIL_UST
- OIL_VALVE
- OIL_VAULT
- OIL_VENT
- SAN_CLEANOUT
- SAN_CONTINUES
- SAN_EOI
- SAN_GREASETRAP
- SAN_INVERT
- SAN_LIFTSTATION
- SAN_MANHOLE
- SAN_MARKER
- SAN_MISC
- SAN_SEPTICTANK
- SAN_VAULT
- SAN_VENT
- STEAM_CONTINUES
- STEAM_EOI
- STEAM_MANHOLE
- STEAM_MISC
- STEAM_VALVE
- STRM_CATCHBASINROUND
- STRM_CATCHBASINSQUARE
- STRM_CLEANOUT
- STRM_CONTINUES
- STRM_CURBINLET
- STRM_ENDPIPE
- STRM_EOI
- STRM_LIFTSTATION
- STRM_MANHOLE
- STRM_MISC
- STRM_ROOFDRAIN
- STRM_TRENCHDRAIN
- STRM_UST
- STRM_VAULT
- STRM_VENT
- STRM_YARDBASIN
- TRAF_BOX
- TRAF_CABINET
- TRAF_CONTINUES
- TRAF_EOI
- TRAF_MANHOLE
- TRAF_MISC
- TRAF_PARKINGMETER
- TRAF_SIGN
- TRAF_SIGNAL
- TRAF_STREETLIGHT
- TREE_CONIFEROUS
- TREE_DECIDUOUS
- UNKN_CONTINUES
- UNKN_EOI
- UNKN_MANHOLE
- UNKN_MISC
- UNKN_VALVE
- WTR_BACKFLOWPREVENTOR
- WTR_CONTINUES
- WTR_EOI
- WTR_HYDRANT
- WTR_MANHOLE
- WTR_METER
- WTR_MISC
- WTR_POSTINDICATORVALVE
- WTR_RISER
- WTR_VALVE
- WTR_WELLHEAD
- BUILDING CORNER
- FLAGPOLE
- GRAVE
- GRAVE
- HEADSTONE NO GRAVE
- MAILBOX
- POST
- SATELLITE
- SIGN
- SOIL BORING MARKER
- SOIL BORING MARKER

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LEGEND

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- WATER

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FOR INFORMATION ONLY

GPRS FINDINGS MAP

PREPARED FOR:
KENNEY GEOTECHNICAL SERVICES

LOCATION:
BINGHAMTON COLLEGE
4400 VESTAL PARKWAY E.
BINGHAMTON, NY

PROJECT MANAGER:
JOE GOODFELLOW
JOE.GOODFELLOW@GPRSINC.COM

DATE	2023 JAN 24
DRAWING NO.	2 **REV.** 2

519224

Project: East Gym Addition - Binghamton University
Project Location: 4400 Vestal Pkwy E. , Binghamton NY
Project Number: 2023-005

Key to Soil Symbols and Terms

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE-GRAINED SOILS (major portions retained on No. 200 sieve): includes (1) clean gravel and sands and (2) silty or clayey gravels and sands. Condition is rated according to relative density as determined by laboratory tests or standard penetration resistance tests.

Descriptive Terms	Relative Density	SPT Blow Count
Very loose	0 to 15 %	< 4
Loose	15 to 35 %	4 to 10
Medium dense	35 to 65 %	10 to 30
Dense	65 to 85 %	30 to 50
Very dense	85 to 100 %	> 50

FINE-GRAINED SOILS (major portions passing on No. 200 sieve): includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings, SPT blow count, or unconfined compression tests.

Descriptive Terms	Unconfined Compressive Strength kPa	SPT Blow Count
Very soft	< 25	< 2
Soft	25 to 50	2 to 4
Medium stiff	50 to 100	4 to 8
Stiff	100 to 200	8 to 15
Very stiff	200 to 400	15 to 30
Hard	> 400	> 30

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.

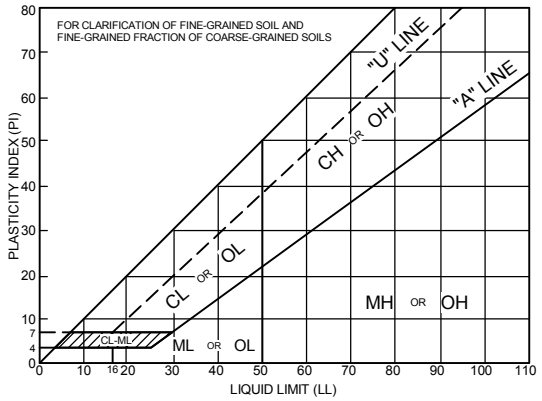
2. Surface elevations are based on topographic maps and estimated locations.

3. Descriptions on these boring logs apply only at the specific boring locations and at the time the borings were made. They are not guaranteed to be representative of subsurface conditions at other locations or times.

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravel (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, Depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent..... GW, GP, SW, SP; More than 12 percent..... GM, GC, SM, SC; 6 to 12 percent..... Borderline case4s requiring dual symbols**
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines	
		Gravel with fines (Appreciable amount of fines)	GM* d / u	Silty gravels, gravel-sand-silt mixtures	
			GC	Clayey gravels, gravel-sand-silt mixtures	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines	
			SP	Poorly-graded sands, gravelly sands, little or no fines	
		Sands with fines (Appreciable amount of fines)	SM* d / u	Silty sands, sand-silt mixtures	
			SC	Clayey sands, sand-clay mixtures	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 60)		ML	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
			OL	Organic silts and organic silty clays of low plasticity	
	Silts and Clays (Liquid limit greater than 60)		MH	Inorganic silts, micaceous or disto-maceous fine sandy or silty soils, organic silts	
			CH	Inorganic clays of high plasticity, fat clays	
			OH	Organic clays of medium to high plasticity, organic silts	
	Highly Organic Soils		Pt	Peat and other highly organic soils	

Laboratory Classification Criteria:

- $C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
- Not meeting all gradation requirements for GW
- Atterberg limits below "A" line or P.I. less than 4 / Atterberg limits above "A" line or P.I. greater than 7 — Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
- $C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
- Not meeting all gradation requirements for SW
- Atterberg limits below "A" line or P.I. less than 4 / Atterberg limits above "A" line or P.I. greater than 7 — Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols



Plasticity Chart

Material	Particle Size mm	Particle Size Sieve sizes
Silt or clay	< 0.074	< #200
Sand	0.074 to 2.00	#200 to #10
Fine	0.074 to 0.42	#200 to #40
Medium	0.42 to 2.00	#40 to #10
Coarse	2.00 to 4.76	#10 to #4
Gravel	4.76 to 76.2	#4 to 12 in.
Fine	4.76 to 19.1	#4 to 3/4 in.
Coarse	19.1 to 76.2	3/4 in. to 12 in.
Cobble	76.2 to 304.8	3 in. to 12 in.
Boulders	304.8 to 914.4	12 in. to 36 in.

* Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg Limits: suffix d used when L.L. is 23 or less and the P.I. is 6 or less; the suffix is used when L.L. is greater than 26.

** Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

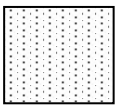
Kenney Geotechnical Services

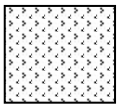
Key to Symbols

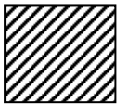
Project Name:	East Gym Addition - Binghamton University
Client:	Delta Engineers, Architects, Surveyors, Landscape Architects, DPC

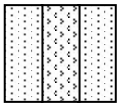
Project Number:	2023-005
Location:	Binghamton, NY

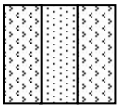
LITHOLOGIC SYMBOLS
(UNIFIED SOIL CLASSIFICATION SYSTEM)

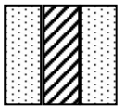

SP/SW: POORLY GRADED/WELL-GRADED SAND

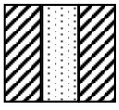

ML: SILT

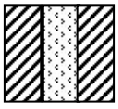

CL: LEAN CLAY

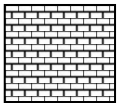

SM: SILTY SAND

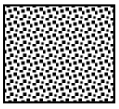

MLS: SANDY SILT

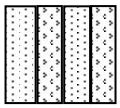

SC: CLAYEY SAND

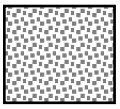

CLS: LOW PLASTICITY SANDY CLAY

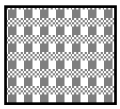

CL-ML: SILTY CLAY OR SANDY SILTY CLAY

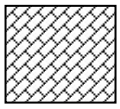

BEDROCK ANY TYPE

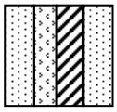

TILL: GLACIAL TILL

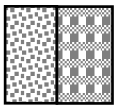

SP-SM: POORLY GRADED SAND WITH SILT

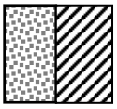

GW/GP: WELL-GRADED GRAVEL AND POORLY GRADED GRAVEL

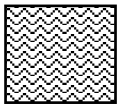

GM/GC: SILTY GRAVEL OR CLAYEY GRAVEL


FILL/OL


SC-SM: SILTY CLAYEY SAND


GP-GM OR GW-GM: POORLY GRADED/WELL-GRADED GRAVEL WITH SILT


GP-GC OR GW-GC: POORLY GRADED/WELL-GRADED GRAVEL WITH CLAY


MARL


PEAT

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	**Project Number:**	2023-005	**Logged By:**	NM	**Boring Number**	B-1
Client:	Delta Engineers, DPC	**Ground Elevation:**	96.0	**Checked By:**	CMK	**Sheet:**	1 OF 2
Location:	Binghamton University	**Drill Rig:**	3126GT	**Depth To Groundwater While Drilling:**			18.0
Started:	1/26/2023	**Drill Method:**	3.25 HSA	**Depth To Groundwater Before Auger Removal:**			18.9
Completed:	1/26/2023	**Driller:**	D. Green	**Depth To Groundwater After Auger Removal:**			DRY

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
	SPT	14	1		5	**TOPSOIL**	0.5		
1			2			**(GC-GM) LOOSE, BROWN SILTY CLAYEY GRAVEL WITH SAND, MOIST**			
			3						
2			2						
	SPT	11	WOH		7	**SIMILAR SOIL, LOOSE, MOIST**	3.0		
3			5						
			2			**(CL-ML) MEDIUM STIFF, BROWN GRAVELLY SILTY CLAY WITH SAND, MOIST**			
4			5						
	SPT	12	2		10	**SIMILAR SOIL, STIFF, MOIST**	5.0		
5			4						
			6			**(GWS) LOOSE, GREY/BROWN WELL GRADED GRAVEL WITH SAND AND SILT, MOIST**			
6			12						
	SPT	12	15		27	**BOULDERS/COBBLES ENCOUNTERED WHILE DRILLING BEGINNING AT 5.0 FT**			
7			12			**SIMILAR SOIL, MEDIUM DENSE, MOIST**			
			15						
8			15						
	SPT	9	12		28	**SIMILAR SOIL, MEDIUM DENSE, MOIST**			
9			14						
			14						
10			14						
11									
12									
13							13.0		
	SPT	0	12		30	**NO RECOVERY**			
14			14						
			16						
15			12				15		
16									
17									
18							18.0		
	SPT	13	3		7	**(SWG) LOOSE, BROWN WELL GRADED SAND WITH GRAVEL AND SILT, WET**			
19			3						
			4						
20			4						

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	**Project Number:**	2023-005	**Logged By:**	NM	**Boring Number**	B-1
Client:	Delta Engineers, DPC	**Ground Elevation:**	96.0	**Checked By:**	CMK	**Sheet:**	2 OF 2
Location:	Binghamton University	**Drill Rig:**	3126GT	**Depth To Groundwater While Drilling:**			18.0
Started:	1/26/2023	**Drill Method:**	3.25 HSA	**Depth To Groundwater Before Auger Removal:**			18.9
Completed:	1/26/2023	**Driller:**	D. Green	**Depth To Groundwater After Auger Removal:**			DRY

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
21									
22									
23							23.0		
	SPT	10	3		5	**(GWS) LOOSE, BROWN WELL GRADED GRAVEL WITH SAND AND SILT, WET**			
24			3						
			2						
25			3						
26									
27									
28									
	SPT	12	14		28	**SIMILAR SOIL, MEDIUM DENSE, WET**			
29			16						
			12						
30			12						

Bottom of Boring: 30.0 FT

Cave Depth: 15.0 FT

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	**Project Number:**	2023-005	**Logged By:**	NM	**Boring Number**	B-2
Client:	Delta Engineers, DPC	**Ground Elevation:**	97.1	**Checked By:**	CMK	**Sheet:**	1 OF 2
Location:	Binghamton University	**Drill Rig:**	3126GT	**Depth To Groundwater While Drilling:**			18.0
Started:	1/26/2023	**Drill Method:**	3.25 HSA	**Depth To Groundwater Before Auger Removal:**			21.3
Completed:	1/26/2023	**Driller:**	D. Green	**Depth To Groundwater After Auger Removal:**			17.1

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
	SPT	6	3		14	**TOPSOIL**	0.5		
1			6			**FILL: (GC-GM) MEDIUM DENSE, SILTY CLAYEY GRAVEL WITHS AND, MOIST**			
			8						
2			7						
	SPT	17	9		33	**SIMILAR SOIL, DENSE, MOIST**			
3			15			**BOULDERS/COBBLES ENCOUNTERED WHILE DRILLING BEGINNING AT 2.0 FT**			
			18						
4			18				4.0		
	SPT	12	24		50	**FILL: (GWS) DENSE, BROWN WELL GRADED GRAVEL WITH SAND AND SILT, MOIST**			
5			32						
			18						
6			14						
	SPT	12	15		37	**FILL: (GWS) DENSE, BROWN WELL GRADED GRAVEL WITH SAND, SILT AND BRICK, MOIST**			
7			18						
			19						
8			20				8.0		
	SPT	13	10		24	**(GWS) MEDIUM DENSE, BROWN WELL GRADED GRAVEL WITH SAND AND SILT, MOIST**			
9			12						
			12						
10			12						
11									
12									
13									
	SPT	6	6		13	**SIMILAR SOIL, MEDIUM DENSE, MOIST**			
14			6						
			7						
15			7						
16									
17									
18									
	SPT	10	10		15	**SIMILAR SOIL, MEDIUM DENSE, MOIST**	19.0		
19			8						
			7			**(CL-ML) STIFF, BROWN SANDY SILTY CLAY WITH GRAVEL, WET**		2.0	
20			6						

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-2
Client:	Delta Engineers, DPC	Ground Elevation:	97.1	Checked By:	CMK	Sheet:	2 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			18.0
Started:	1/26/2023	Drill Method:	3.25 HSA	Depth To Groundwater Before Auger Removal:			21.3
Completed:	1/26/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			17.1

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
21									
22									
23							23.0		
24	SPT	7	5 9 11 6		20	(GC-GM) MEDIUM DENSE, BROWN SILTY CLAYEY GRAVEL WITH SAND, WET			
25									
26									
27									
28									
29	SPT	17	4 5		11	SIMILAR SOIL, MEDIUM DENSE, WET	29.0		
30			6 6			(MLS) MEDIUM DENSE, BROWN SANDY SILT WITH GRAVEL, WET			

Bottom of Boring: 30.0 FT | Cave Depth: 19.5 FT

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-3
Client:	Delta Engineers, DPC	Ground Elevation:	97.5	Checked By:	CMK	Sheet:	1 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			18.0
Started:	1/26/2023	Drill Method:	3.25 HSA	Depth To Groundwater Before Auger Removal:			26.2
Completed:	1/26/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			DRY

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
						TOPSOIL - HAND EXCAVATED	0.5		
1	SPT	17	6		11	**(GC-GM) MEDIUM DENSE, BROWN SILTY CLAYEY GRAVEL WITH SAND, MOIST**			9.7
			5						
2			7				2.0		
	SPT	8	2		12	**(CL-ML) STIFF, BROWN SILTY CLAY WITH SAND, MOIST**			19.3
3			2						
			10						
4			9				4.0		
	SPT	15	4		13	**(SC-SM) MEDIUM DENSE, BROWN SILTY CLAYEY SAND WITH GRAVEL, MOIST BOULDERS/COBBLES ENCOUNTERED WHILE DRILLING BEGINNING AT 5.0 FT**			16.0
5			7						
			6						
6			11				6.0		
	SPT	18	11		22	**(GWS) MEDIUM DENSE, BROWN WELL GRADED GRAVEL WITH SAND AND SILT, MOIST**			6.1
7			11						
			11						
8			16						
	SPT	14	12		31	**SIMILAR SOIL, DENSE, MOIST**			6.2
9			14						
			17						
10			11						
11									
12									
13							13.0		
	SPT	0	12		27	**NO RECOVERY**			
14			12						
			15						
15			15				15.0		
16									
17									
18							18.0		
	SPT	13	3		16	**(GWS) MEDIUM DENSE, BROWN WELL GRADED GRAVEL WITH SAND AND SILT, WET**			14.2
19			6						
			10						
20			8						

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-3
Client:	Delta Engineers, DPC	Ground Elevation:	97.5	Checked By:	CMK	Sheet:	2 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			18.0
Started:	1/26/2023	Drill Method:	3.25 HSA	Depth To Groundwater Before Auger Removal:			26.2
Completed:	1/26/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			DRY

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
21									
22									
23							23.0		
24	SPT	20	8 7 18 14		25	(SWG) MEDIUM DENSE, BROWN WELL GRADED SAND WITH GRAVEL AND SILT, WET			17.8
25									
26									
27									
28									
29	SPT	21	6 12 13 20		25	SIMILAR SOIL, MEDIUM DENSE, WET GLACIAL TILL: (GC-GM) MEDIUM DENSE, GREY SILTY CLAYEY GRAVEL WITH SAND, MOIST	24.0		
30									

Bottom of Boring: 30.0 FT

Cave Depth: 18.1 FT

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-4
Client:	Delta Engineers, DPC	Ground Elevation:	97.1	Checked By:	CMK	Sheet:	1 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			18.0
Started:	1/27/2023	Drill Method:	2.75 OTE	Depth To Groundwater Before Auger Removal:			19.7
Completed:	1/27/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			DRY

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
	SPT	16	3		12	**TOPSOIL**	0.5		
1			5			**FILL: (CL-ML) STIFF, BROWN GRAVELLY SILTY CLAY WITH SAND, MOIST**			
			7						
2			7						
	SPT	14	4		13	**FILL: SIMILAR SOIL, STIFF, MOIST**	2.8		
3			4			**(OL) STIFF, DARK BROWN ORGANIC SILTY CLAY WITH SAND, MOIST**			
			9						
4			11				4.0		
	SPT	14	9		23	**(GM) MEDIUM DENSE, BROWN SILTY GRAVEL WITH SAND, MOIST**			
5			11						
			12						
6			15						
	SPT	13	15		32	**SIMILAR SOIL, DENSE, MOIST BOULDERS/COBBLES ENCOUNTERED WHILE DRILLING BEGINNING AT 5.0 FT**			
7			16						
			16						
8			18						
	SPT	15	20		32	**SIMILAR SOIL, DENSE, MOIST**			
9			15						
			17						
10			17						
11									
12									
13									
	SPT	4	6		18	**SIMILAR SOIL, MEDIUM DENSE, MOIST**			
14			7						
			11						
15			15						
16									
17									
18							18.0		
	SPT	8	4		13	**(GWS) MEDIUM DENSE, BROWN WELL GRADED GRAVEL WITH SAND AND SILT, WET**			
19			6						
			7						
20			9						

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-4
Client:	Delta Engineers, DPC	Ground Elevation:	97.1	Checked By:	CMK	Sheet:	2 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			18.0
Started:	1/27/2023	Drill Method:	3.25 HSA	Depth To Groundwater Before Auger Removal:			19.7
Completed:	1/27/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			DRY

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
21									
22									
23									
	SPT	10	4		11	**SIMILAR SOIL, MEDIUM DENSE, WET**			
24			5						
			6						
25			9						
26									
27									
28							28.0		
	SPT	13	16		28	**GLACIAL TILL: (GC-GM) MEDIUM DENSE, GREY SILTY CLAYEY GRAVEL WITH SAND, MOIST**			
29			12						
			16						
30			14						

Bottom of Boring: 30.0 FT

Cave Depth: 16.4 FT

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-5
Client:	Delta Engineers, DPC	Ground Elevation:	97.8	Checked By:	CMK	Sheet:	1 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			15.5
Started:	1/23/2023	Drill Method:	3.25 HSA	Depth To Groundwater Before Auger Removal:			23.8
Completed:	1/23/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			15.1

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
						TOPSOIL - HAND DIG	0.5		
1	SPT	15	6		16	(GC-GM) MEDIUM DENSE, BROWN SILTY CLAYEY GRAVEL WITH SAND, WET TO MOIST			
			10						
2			8						
	SPT	18	16		27	SIMILAR SOIL, MEDIUM DENSE, MOIST	2.5		
3			17			(SC-SM) MEDIUM DENSE, BROWN SILTY CLAYEY SAND WITH GRAVEL, MOIST			
			10						
4			9						
	SPT	13	12		22	SIMILAR SOIL, MEDIUM DENSE, MOIST BOULDERS/COBBLES ENCOUNTERED WHILE DRILLING BEGINNING AT 5.0 FT			
5			10						
			12						
6			14				6.0		
	SPT	16	12		28	(SW-SM) BROWN MEDIUM DENSE, WELL GRADED SAND WITH SILT AND GRAVEL, MOIST			
7			14						
			14						
8			24				8.0		
	SPT	12	16		26	(GWS) MEDIUM DENSE, BROWN WELL GRADED GRAVEL WITH SAND AND SILT, MOIST			
9			14						
			12						
10			12						
11									
12									
13									
	SPT	13	12		32	SIMILAR SOIL, DENSE, MOIST OBSTRUCTION AT 15.5 FT			
14			20						
			12						
15			10						
15.5	SPT	15	10		26	SIMILAR SOIL, MEDIUM DENSE, WET			
16			12						
			14						
17			18						
18									
	SPT	17	10		20	SIMILAR SOIL, MEDIUM DENSE ,WET			
19			10						
			10						
20			7						

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-5
Client:	Delta Engineers, DPC	Ground Elevation:	97.8	Checked By:	CMK	Sheet:	2 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			15.5
Started:	1/23/2023	Drill Method:	3.25 HSA	Depth To Groundwater Before Auger Removal:			23.8
Completed:	1/23/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			15.1

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
21									
22									
23							23.0		
24	SPT	12	8 10		25	**GLACIAL TILL: (CL-ML) VERY STIFF, GREY GRAVELLY SILTY CLAY WITH SAND, MOIST**		3.75	
25			15 17						
26									
27									
28							28.0		
29	SPT	12	13 14		32	**GLACIAL TILL: (GC-GM) DENSE, GREY SILTY CLAYEY GRAVEL WITH SAND, MOIST**			
30			18 18						

Bottom of Boring: 30.0 FT

Cave Depth: 16.2 FT

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-6
Client:	Delta Engineers, DPC	Ground Elevation:	97.3	Checked By:	CMK	Sheet:	1 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			DRY
Started:	1/23/2023	Drill Method:	3.25 HSA	Depth To Groundwater Before Auger Removal:			DRY
Completed:	1/23/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			DRY

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
						TOPSOIL - HAND DIG	0.5		
1	SPT	11	2		14	**(GM) MEDIUM DENSE, GREY SILTY GRAVEL WITH SAND, WET**	0.9		
			12						
2			26			**(GWS) MEDIUM DENSE, GREY/BROWN WEL GRADED GRAVEL WITH SAND AND SILT, MOIST**			
	SPT	17	16		44	**SIMILAR SOIL, DENSE, MOIST**			
3			24						
			20			**BOULDERS/COBBLES ENCOUNTERED WHILE DRILLING BEGINNING AT 2.0 FT**			
4			28						
	SPT	8	16		48				
5			24			**SIMILAR SOIL, DENSE, MOIST**			
			24						
6			24						
	SPT	17	18		48				
7			24			**SIMILAR SOIL, DENSE, MOIST**			
			24						
8			20						
	SPT	13	16		40				
9			18			**SIMILAR SOIL, DENSE, MOIST**			
			22						
10			24						
11									
12									
13							13.0		
	SPT	2	58		100	**(GP) VERY DENSE, GREY POORLY GRADED GRAVEL (APPARENT COBBLE/BOULDER), MOIST**			
14			50						
			50/0.3						
15									
						AUGER REFUSAL ENCOUNTERED AT 16.0 FT	16.0		
16		0	50/0.2		100	**NO RECOVERY**			

Bottom of Boring: 16.2 FT | Cave Depth: 9.8 FT

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-7
Client:	Delta Engineers, DPC	Ground Elevation:	98.0	Checked By:	CMK	Sheet:	1 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			18.0
Started:	1/24/2023	Drill Method:	3.25 HSA	Depth To Groundwater Before Auger Removal:			25.9
Completed:	1/26/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			N/A

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
						TOPSOIL	0.7		
1	SPT	2	5		16	**(GC-GM) MEDIUM DENSE, BROWN SILTY CLAYEY GRAVEL WITH SAND, MOIST**			
			11						
2			15						
	SPT	20	11		31	**SIMILAR SOIL, DENSE, MOIST**			
3			17			**BOULDERS/COBBLES ENCOUNTERED WHILE DRILLING BEGINNING AT 2.0 FT**			
			14						
4			12				4.0		
	SPT	12	14		36	**(GM) DENSE, BROWN SILTY GRAVEL WITH SAND, MOIST**			
5			17						
			19						
6			11						
	SPT	11	9		20	**SIMILAR SOIL, MEDIUM DENSE, MOIST**			
7			9						
			11						
8			17						
	SPT	15	16		25	**SIMILAR SOIL, MEDIUM DENSE, MOIST**			
9			12						
			13						
10			10						
11									
12									
13									
	SPT	10	15		27	**SIMILAR SOIL, MEDIUM DENSE, MOIST**			
14			17						
			10						
15			10						
16									
17									
18							18.0		
	SPT	8	4		19	**(GC-GM) MEDIUM DENSE, BROWN SILTY CLAYEY GRAVEL WITH SAND, WET**			
19			9						
			10						
20			12						

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	**Project Number:**	2023-005	**Logged By:**	NM	**Boring Number**	B-7
Client:	Delta Engineers, DPC	**Ground Elevation:**	98.0	**Checked By:**	CMK	**Sheet:**	2 OF 2
Location:	Binghamton University	**Drill Rig:**	3126GT	**Depth To Groundwater While Drilling:**			18.0
Started:	1/24/2023	**Drill Method:**	3.25 HSA	**Depth To Groundwater Before Auger Removal:**			25.9
Completed:	1/26/2023	**Driller:**	D. Green	**Depth To Groundwater After Auger Removal:**			N/A

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
21									
22									
23									
	SPT	12	7		19	**SIMILAR SOIL, MEDIUM DENSE, GREY, WET**			
24			9						
			10						
25			10						
26									
27									
28									
	SPT	10	14		23	**SIMILAR SOIL, MEDIUM DENSE, WET**			
29			9						
			14						
30			14						

NOTES:

Bottom of Boring: 30.0 FT

Cave Depth: 16.4 FT

One inch PVC, temporary piezometer installed at 28.0 feet. Piezometer consisted of 15 feet of screen encapsulated with filter sand followed by 15 feet of riser. Bentonite plug installed above screen and backfilled with auger cuttings.

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-8
Client:	Delta Engineers, DPC	Ground Elevation:	97.9	Checked By:	CMK	Sheet:	1 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			DRY
Started:	1/24/2023	Drill Method:	3.25 HSA	Depth To Groundwater Before Auger Removal:			25.6
Completed:	1/24/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			DRY

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
						TOPSOIL	0.5		
1	SPT	10	4		8	**(GM) LOOSE, BROWN SILTY GRAVEL WITH SAND, MOIST**			
			4						
2			12						
	SPT	15	5		22	**SIMILAR SOIL, MEDIUM DENSE, MOIST BOULDERS/COBBLES ENCOUNTERED WHILE DRILLING BEGINNING AT 2.0 FT**			
3			11						
			11						
4			17						
	SPT	19	15		34	**SIMILAR SOIL, DENSE, MOIST**			
5			18						
			16						
6			16						
	SPT	8	13		54	**SIMILAR SOIL, VERY DENSE, MOIST**			
7			24						
			30						
8			16						
	SPT	8	16		38	**SIMILAR SOIL, DENSE, MOIST**			
9			20						
			18						
10			18						
11									
12									
13									
	SPT	10	26		100	**SIMILAR SOIL, VERY DENSE, MOIST**			
14			26						
			50/0.4						
15									
16									
17									
18							18.0		
	SPT	12	13		31	**GLACIAL TILL: (GC-GM) DENSE, GREY SILTY CLAYEY GRAVEL WITH SAND, MOIST**			
19			15						
			16						
20			20						

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-8
Client:	Delta Engineers, DPC	Ground Elevation:	97.9	Checked By:	CMK	Sheet:	1 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			DRY
Started:	1/24/2023	Drill Method:	3.25 HSA	Depth To Groundwater Before Auger Removal:			25.6
Completed:	1/24/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			DRY

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
21									
22									
23									
			20						
24	SPT	18	24		58	**SIMILAR SOIL, VERY DENSE, MOIST**			
			34			**AUGER REFUSAL AT 25.2 FT**			
25			50						
25.2			25						
26	SPT	17	30		55	**SIMILAR SOIL, VERY DENSE, MOIST**			
			25						
27			25						

Bottom of Boring: 27.2 FT

Cave Depth: 20.5 FT

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	Project Number:	2023-005	Logged By:	NM	Boring Number	B-9
Client:	Delta Engineers, DPC	Ground Elevation:	98.3	Checked By:	CMK	Sheet:	1 OF 2
Location:	Binghamton University	Drill Rig:	3126GT	Depth To Groundwater While Drilling:			DRY
Started:	1/24/2023	Drill Method:	3.25 HSA	Depth To Groundwater Before Auger Removal:			DRY
Completed:	1/24/2023	Driller:	D. Green	Depth To Groundwater After Auger Removal:			DRY

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
						TOPSOIL	0.5		
1	SPT	17	12		26	**(GC-GM) MEDIUM DENSE, BROWN SILTY CLAYEY GRAVEL WITH SAND, MOIST**			
			14						
2			14						
	SPT	20	8		19	**SIMILAR SOIL, MEDIUM DENSE, MOIST**			
3			9			**BOULDERS/COBBLES ENCOUNTERED WHILE DRILLING BEGINNING AT 2.0 FT**			
			10						
4			10						
	SPT	13	26		28				
5			15			**SIMILAR SOIL, MEDIUM DENSE, MOIST**			
			13						
6			24				6.0		
	SPT	17	12		22	**(SC-SM) MEDIUM DENSE, BROWN SILTY CLAYEY SAND WITH GRAVEL, MOIST**			
7			12						
			10						
8			12				8.0		
	SPT	13	34		25	**(GM) MEDIUM DENSE, BROWN SILTY GRAVEL WITH SAND, MOIST**			
9			12						
			13						
10			11						
11									
12									
13							13.0		
	SPT	0	10		38	**NO RECOVERY**			
14			16						
			22						
15			28				15.0		
16									
17									
17.8						**AUGER REFUSAL AT 17.8 FT**			
18	SPT	5	47		100	**(GP) VERY DENSE, GREY POORLY GRADED GRAVEL, MOIST (APPARENT COBBLE/BOULDER CHIPS)**			
			50/0.3						

Bottom of Boring: 18.8 FT | Cave Depth: 20.5 FT

Kenney Geotechnical Services

Geotechnical Boring Log

Project Name:	East Gym Addition	**Project Number:**	2023-005	**Logged By:**	NM	**Boring Number**	B-10
Client:	Delta Engineers, DPC	**Ground Elevation:**	100.0	**Checked By:**	CMK	**Sheet:**	1 OF 2
Location:	Binghamton University	**Drill Rig:**	3126GT	**Depth To Groundwater While Drilling:**			13.0
Started:	1/27/2023	**Drill Method:**	2.75 OTE	**Depth To Groundwater Before Auger Removal:**			10.4
Completed:	1/27/2023	**Driller:**	D. Green	**Depth To Groundwater After Auger Removal:**			8.5

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
	SPT	15	3		12	**TOPSOIL**	0.5		13.4
1			6			**(GC-GM) MEDIUM DENSE, BROWN SILTY CLAYEY GRAVEL WITH SAND, MOIST**			
			6						
2			5				2.0		
	SPT	15	5		11	**(SM) MEDIUM DENSE, SILTY SAND WITH GRAVEL, MOIST**			14.4
3			5						
			6						
4			11				4.0		
	SPT	13	10		16	**(GWS) MEDIUM DENSE, BROWN WELL GRADED GRAVEL WITH SAND AND SILT, MOIST**			6.7
5			10						
			6						
6			6						
	SPT	9	7		15	**SIMILAR SOIL, MEDIUM DENSE, MOIST**			7.6
7			7						
			8						
8			12						
	SPT	16	8		16	**SIMILAR SOIL, MEDIUM DENSE, MOIST**	9.0		8.1
9			8						
			8			**(SWG) MEDIUM DENSE, BROWN WELL GRADED SAND WITH GRAVEL, MOIST**			
10			8						
11									
12									
13									
14							13.0		
	SPT	13	36		56	**SIILAR SOIL, VERY DENSE, WET**	14.0		8.5
15			28						
			28			**(GM) VERY DENSE, BROWN SILTY GRAVEL WITH SAND, WET**			
16			50						
17									
18									
19									
	SPT	↓	50		↓	**(GWS) VERY DENSE, GREY WELL GRADED GRAVEL WITH SAND AND SILT, MOIST**			5.4
20			50						

Kenney Geotechnical Services

Geotechnical Boring Log

Continuted on Next Page ↓

Project Name:	East Gym Addition	**Project Number:**	2023-005	**Logged By:**	NM	**Boring Number**	B-10
Client:	Delta Engineers, DPC	**Ground Elevation:**	100.0	**Checked By:**	CMK	**Sheet:**	2 OF 2
Location:	Binghamton University	**Drill Rig:**	3126GT	**Depth To Groundwater While Drilling:**			13.0
Started:	1/27/2023	**Drill Method:**	2.75 OTE	**Depth To Groundwater Before Auger Removal:**			10.4
Completed:	1/27/2023	**Driller:**	D. Green	**Depth To Groundwater After Auger Removal:**			8.5

Depth (ft)	Sample Type	Recovery (inch)	Blow Count Per 6 inches	Graphic Log	N (bpf)	USCS Material Description	Strata Change Depth (ft.)	Pocket Penet. (tsf)	Moisture Content (%)
	SPT	5	38		88	**(GWS) VERY DENSE, GREY WELL GRADED GRAVEL WITH SAND AND SILT, MOIST**			
21			24						
22						**(CL-ML) GREY GRAVELY SILTY CLAY WITH SAND RETRIEVED IN OTE SAMPLER**			9.2
23						**CASING REFUSAL AT 23.8 FT**	23.8		
23.8	SPT	3	50/0.4		100	**(GW) VERY DENSE, DARK GREY ROCK FRAGMENTS**			4.7

Bottom of Boring: 24.2 FT | Cave Depth: 22.7 FT

Kenney Geotechnical Engineering Services, PLLC
Office: 6901 Herman Road, Syracuse, NY 13209
Mail :P.O. Box 117 Warners, NY 13164
Phone: (315) 638-2706 Fax: (315) 638-1544

Kenney Geotechnical Services

INFILTRATION TEST RESULTS

Project Name:		East Gym Addition – Binghamton University	
Project Number:		2023-005	
Location		4400 Vestal Pkwy E., Binghamton NY	
Date of Test:		1/27/2023	
Test	Depth	Stabilized Rate	Soil Conditions Encountered
-	(ft)	in/hr	USCS
IT-1	8	6	GWS with Silt
IT-2	8	3	GM with Sand

MEASURED INFILTRATION RATES

Test	Hour 1 (in/hr)	Hour 2 (in/hr)	Hour 3 (in/hr)	Hour 4 (in/hr)	Stabilized Rate (in/hr)
IT-1	24	13	6	6	6
IT-2	12	3	3	3	3

LABORATORY TESTING RESULTS

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Mail :P.O. Box 117 Warners, NY 13164
Phone: (315) 638-2706 Fax: (315) 638-1544

Kenney Geotechnical Services

Project No.:	**2023-005**	**Date:**	**2/1/2023**
Project Name:	**Binghamton University - East Gym Addtion**		

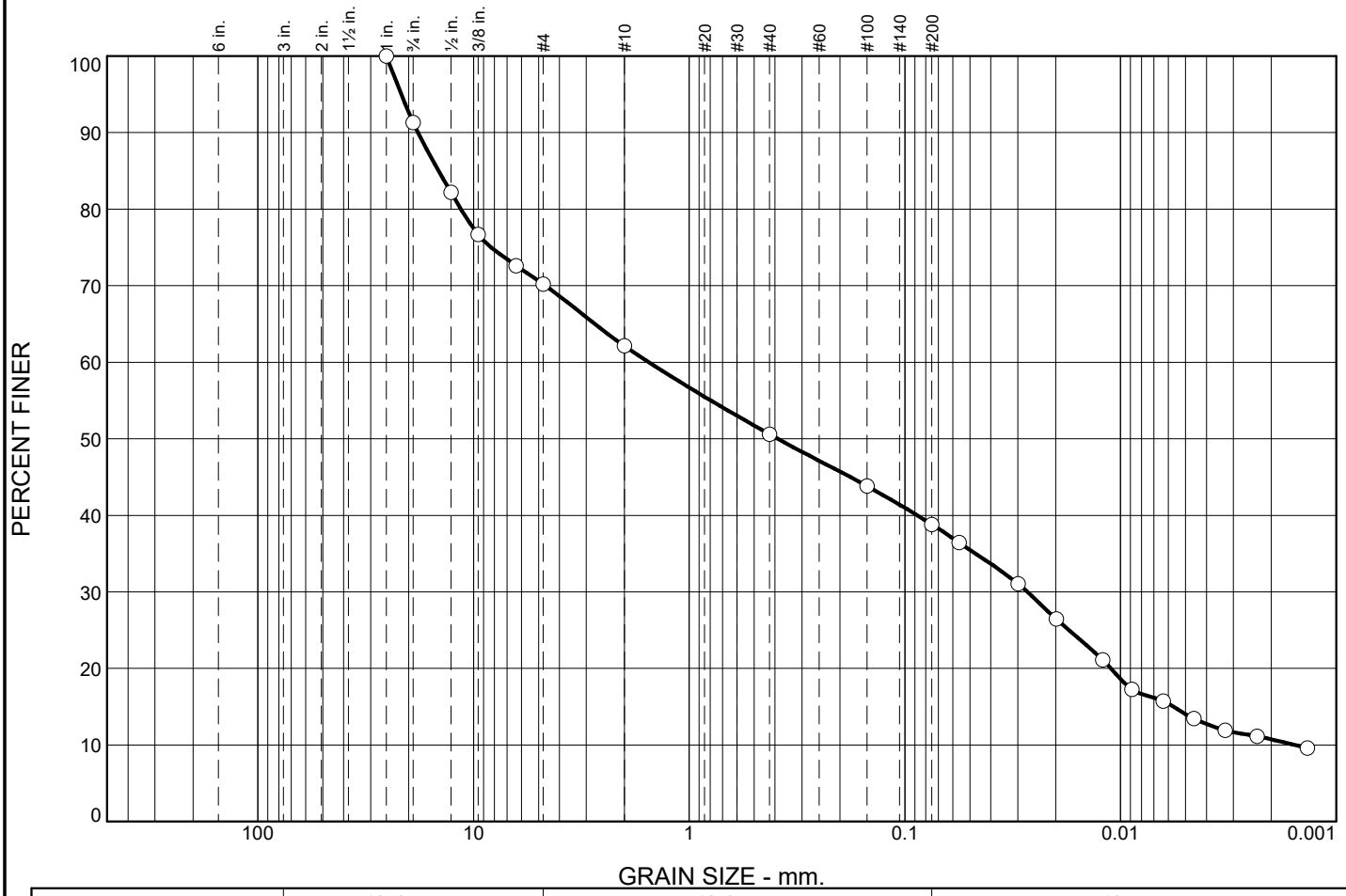
Natural Moisture Content
ASTM D2216

Sample:	**B-10, 0'-2'**	**B-10, 2'-4'**	**B-10, 4'-6'**	**B-10, 6'-8'**	**B-10, 8'-10'**	**B-10, 14'-16'**	**B-10, 18'-21'**	**B-10, 21'-23.8'**	**B-10, 23.8'**
Tare Name:	Tina	Abe	Husky	NCIS	Fred	Moo	Link	Oil	Doe
Tare Weight:	14.74	14.29	14	14.59	14.54	14.18	14.37	13.7	14.26
Tare + Wet Sample Wt.:	55.6	57.3	58.86	58.09	51.95	59.94	57.06	54.49	58.29
Tare + Dry Sample Wt.:	50.77	51.88	56.03	55.01	49.15	56.37	54.86	51.04	56.33
H20 Wt.:	4.8	5.4	2.8	3.1	2.8	3.6	2.2	3.5	2.0
Dry Sample Wt.:	36.0	37.6	42.0	40.4	34.6	42.2	40.5	37.3	42.1
MC = (H20 Wt. / Dry Sample Wt.) x 100:	13.4	14.4	6.7	7.6	8.1	8.5	5.4	9.2	4.7

Sample:	**B-3, 0'-2'**	**B-3, 2'-4'**	**B-3, 4'-6'**	**B-3, 6'-8'**	**B-3, 8'-10'**	**B-3, 18'-20'**	**B-3, 23'-25'**	**B-3, 28'-30'**
Tare Name:	Pig	RMB	GAS	WGAS	Larry	CMK1	Sox	RAY
Tare Weight:	14.38	14.19	14.25	13.88	14.35	13.78	14.29	14.07
Tare + Wet Sample Wt.:	62.33	49.91	56.19	66.21	65.77	59.17	69	71.01
Tare + Dry Sample Wt.:	58.08	44.14	50.41	63.21	62.77	53.54	60.7	67.19
H20 Wt.:	4.3	5.8	5.8	3.0	3.0	5.6	8.3	3.8
Dry Sample Wt.:	43.7	30.0	36.2	49.3	48.4	39.8	46.4	53.1
MC = (H20 Wt. / Dry Sample Wt.) x 100:	9.7	19.3	16.0	6.1	6.2	14.2	17.9	7.2

Particle Size Distribution Report

ASTM D422 & D1140



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	8.7	21.1	8.1	11.5	11.8	28.1	10.7

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			14.5310	1.5394	0.3895	0.0270	0.0057	0.0016	0.31	990.52

Material Description	Test Date	USCS	NM
○ Sandy Silt with Gravel and Clay		SM	

Project No. 2023-005 **Client:** Delta Engineers

Project: Binghamton University - East Gym Addition

○ **Source of Sample:** B-4 **Depth:** 29.0' **Sample Number:** 28.0'-30.0'

Remarks:

○ Kenney Geotechnical
Engineering Services, PLLC
6901 Herman Road
Syracuse, NY 13209
(315) 638-2706

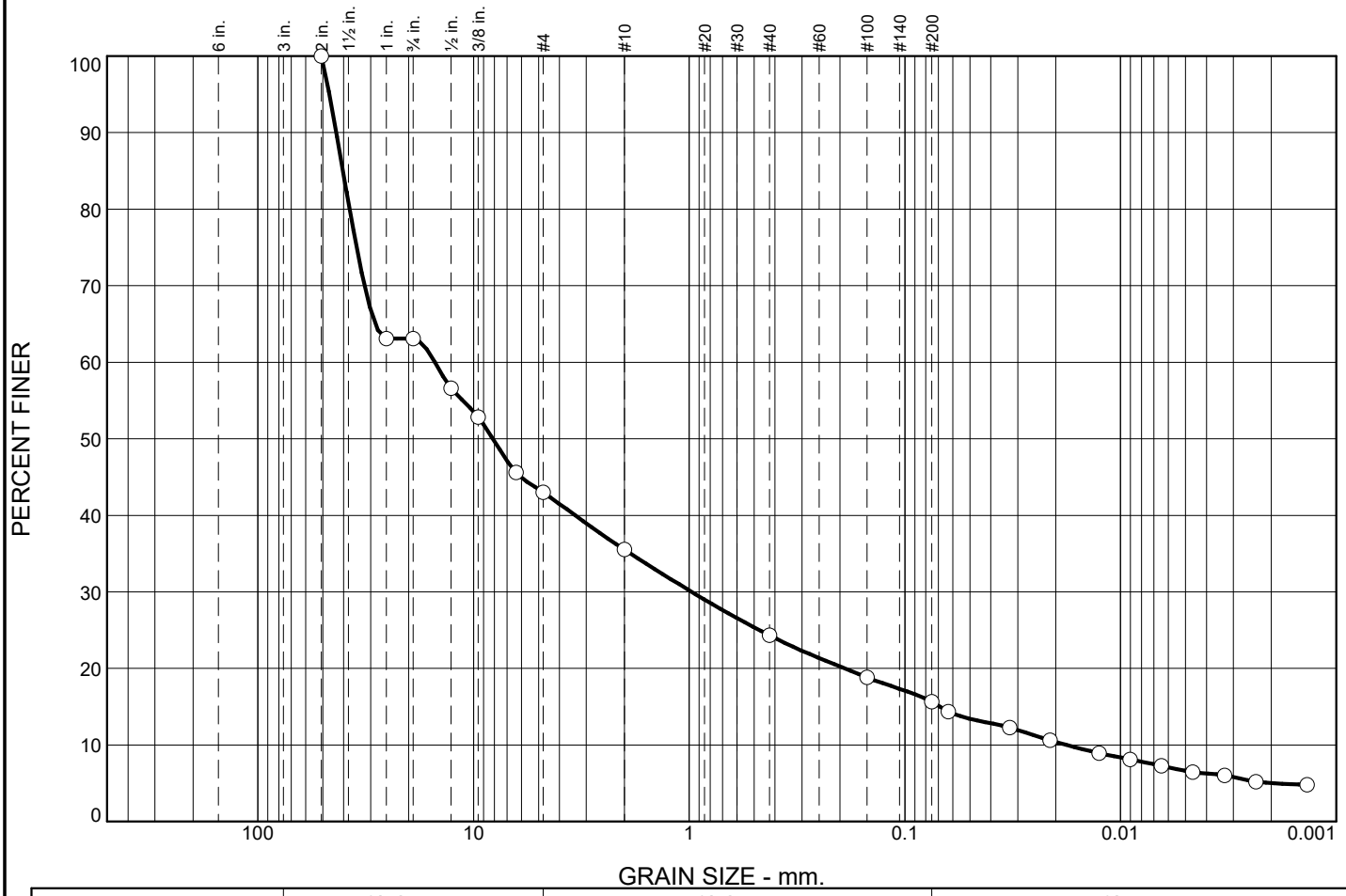
Kenney Geotechnical Services

Figure

Tested By: BE **Checked By:** CMK

Particle Size Distribution Report

ASTM D422 & D1140



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	36.9	20.1	7.5	11.2	8.6	10.7	5.0

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			40.3447	15.1229	8.1387	0.9743	0.0688	0.0178	3.53	850.82

Material Description	Test Date	USCS	NM
○ Clayey Silty Gravel with Sand	2/2/23	GC-GM	

Project No. 2023-005 **Client:** Delta Engineers

Project: Binghamton University - East Gym Addition

○ **Source of Sample:** B-5 **Depth:** 9.0' **Sample Number:** 8.0'-10.0'

Remarks:

○ Kenney Geotechnical
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Syracuse, NY 13209
(315) 638-2706

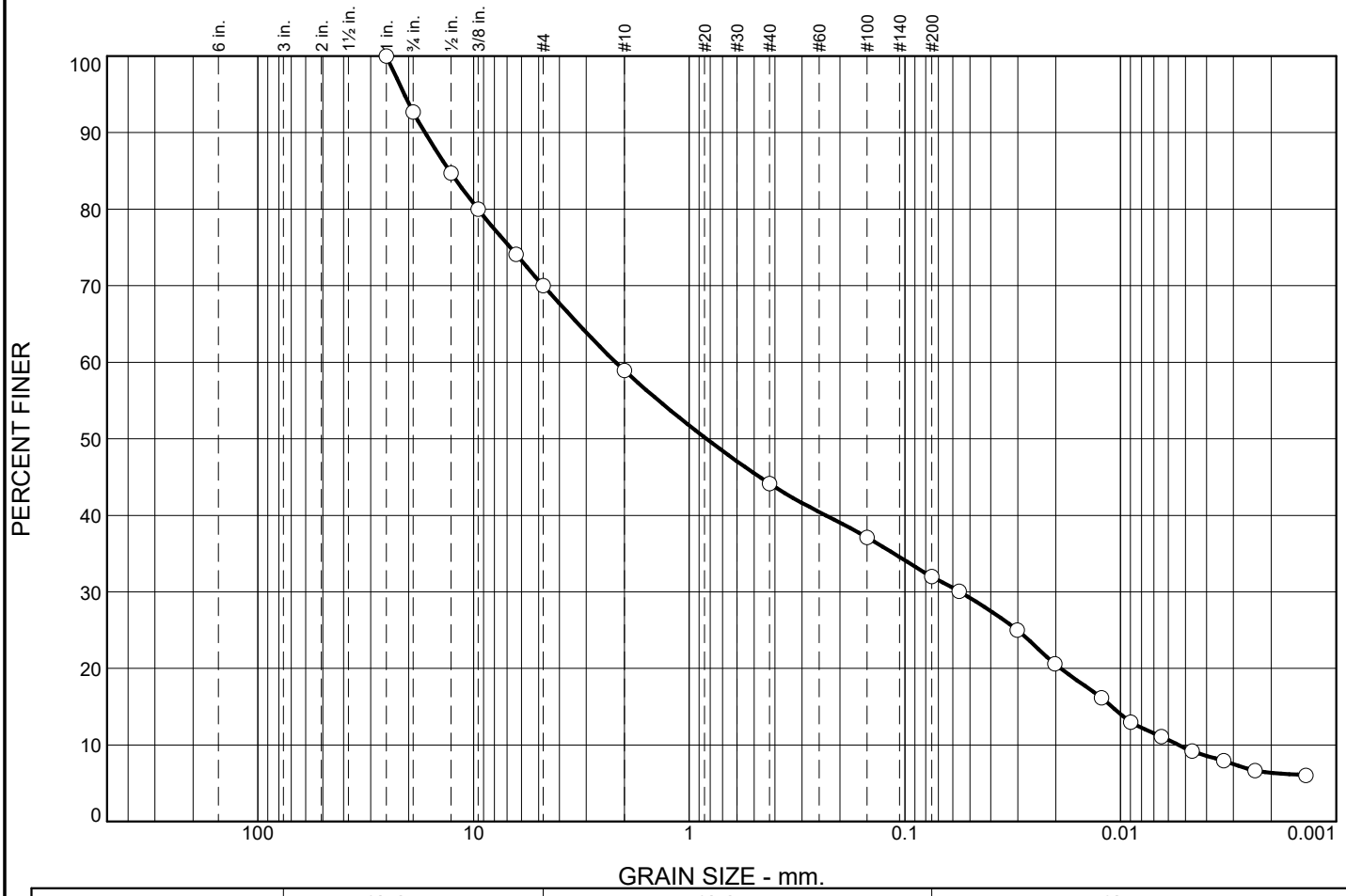
Kenney Geotechnical Services

Figure

Tested By: BE **Checked By:** CMK

Particle Size Distribution Report

ASTM D422 & D1140



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	7.3	22.7	11.1	14.7	12.2	25.6	6.4

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			12.9125	2.1964	0.8324	0.0555	0.0110	0.0054	0.26	407.85

Material Description	Test Date	USCS	NM
○ Silty Sand with Gravel	2/2/23	SM	

Project No. 2023-005 **Client:** Delta Engineers

Project: Binghamton University - East Gym Addition

○ **Source of Sample:** B-7 **Depth:** 7.0' **Sample Number:** 6.0'-8.0'

Remarks:

○ Kenney Geotechnical
Engineering Services, PLLC
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Syracuse, NY 13209
(315) 638-2706

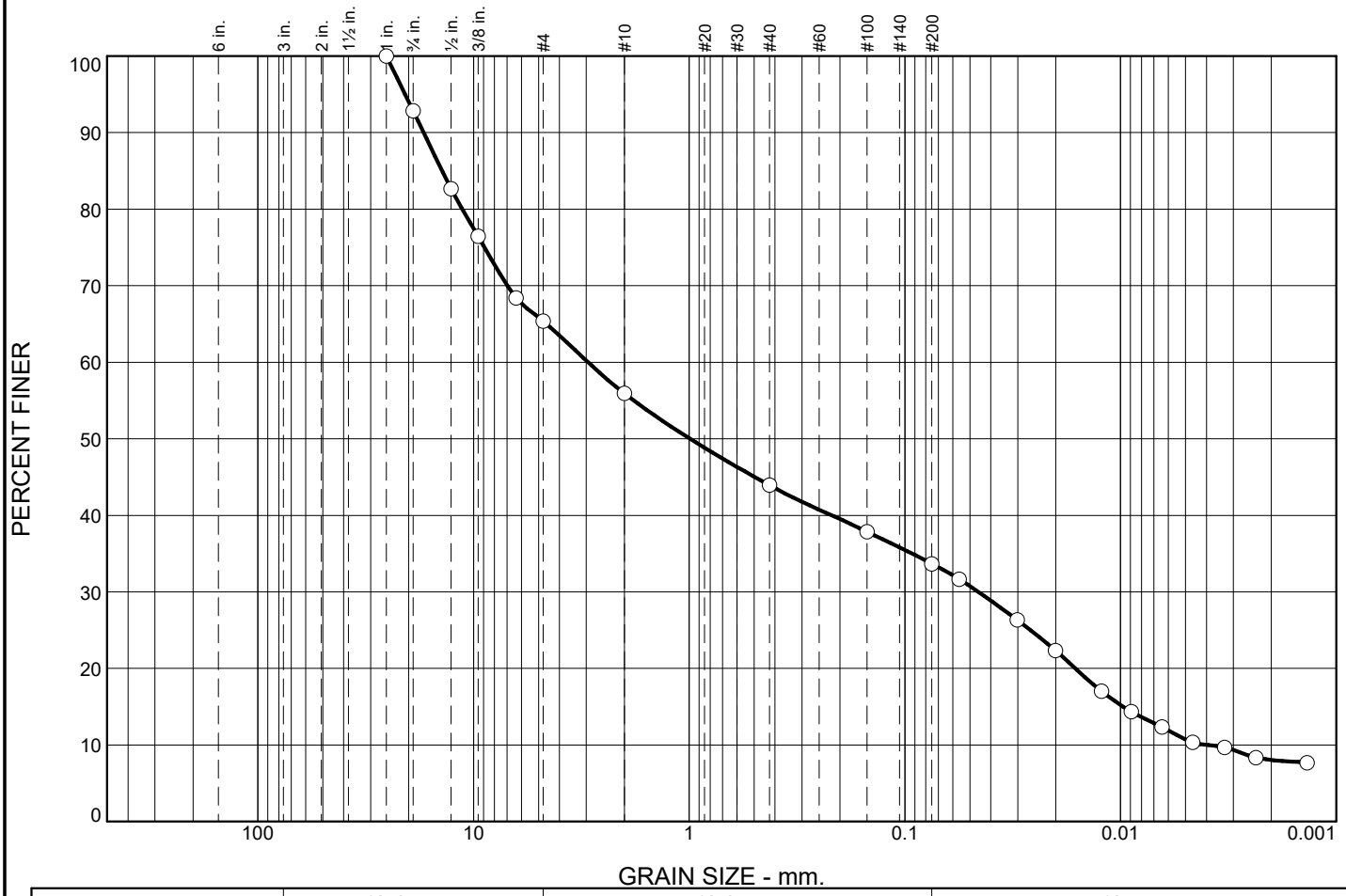
Kenney Geotechnical Services

Figure

Tested By: BE **Checked By:** CMK

Particle Size Distribution Report

ASTM D422 & D1140



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	7.2	27.4	9.5	12.0	10.2	25.7	8.0

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			13.9953	2.9454	0.9915	0.0456	0.0097	0.0040	0.18	738.90

Material Description	Test Date	USCS	NM
○ Clayey Silty Gravel with Sand	2/2/23	GC-GM	

Project No. 2023-005 **Client:** Delta Engineers

Project: Binghamton University - East Gym Addition

○ **Source of Sample:** B-8 **Depth:** 24.0' **Sample Number:** 23.0'-25.0'

Remarks:

○ Kenney Geotechnical
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Figure

Tested By: BE **Checked By:** CMK

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