VOLUME 3 – ENGINEERING

Owego Apalachin Central School District

1 Sheldon Guile Boulevard, Owego NY 13827

Capital Project Phase 3A
Owego Free Academy / Middle School
SED#: 60-06-01-06-0-009-033

"The design of this project conforms to all applicable provisions of the New York State Uniform Fire Prevention and Building Code, the New York State Energy Conservation Code, and the building standards of the New York State Education Department."

HA PN: 2024-240 **APRIL 1, 2025**

OWEGO APALACHIN CSD
CAPTIAL PROJECT – PHASE 3A
OWEGO FREE ACADEMY / MIDDLE SCHOOL
SED#: 60-06-01-06-0-009-033

APRIL 1, 2025

TABLE OF CONTENTS
HA PN: 2024-240P

END OF TABLE OF CONTENTS

SECTION 23 00 00 - HVAC SCOPE OF WORK

PART 1 - GENERAL

1.1 STIPULATIONS

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

1.2 REQUIREMENTS

A. The conditions as defined in Division 23 – Common Work Results for HVAC, shall apply to all Division 23 specifications.

B. This contractor shall carefully read the above mentioned documents and study the drawings of all trades. He shall be responsible for neglect to read, or attend to any paragraph or items contained herein.

1.3 INTENT

A. It is the intent of this specification and accompanying drawings to provide HVAC system, as specified herein and as shown on the contract drawings. The drawings show the general arrangement and extent of the work to be done. Exact location and arrangement of all components shall be determined as the work progresses. Plans are subject to such modification as may be necessary at the time of installation in order to meet construction conditions. Any adjustments shall be made by the HVAC Contractor, without extra charge.

B. The project is to be completed during normal working hours.

1.4 WORK INCLUDED

A. These specifications and accompanying drawings are intended to cover the furnishing by this Contractor of all labor, material and equipment of every kind necessary for the complete installation of the various systems and such other material and equipment as hereinafter specified and shall not be limited to the following:

1. Provide packaged water source heat pump and gas fired rooftop air conditioning units with roof curbs.
2. Provide water to water heat pumps.
3. Provide pipe fittings, valves and specialties for hot water heating piping.
4. Provide grilles, registers and diffusers.
5. Provide dampers, turning vanes, louvers and other ductwork accessories for all airside systems.

6. Provide ventilating equipment consisting of power roof ventilators and other fans as needed for all airside systems.
7. Provide balancing fittings, air vents, unions, strainers, thermometers, pressure gauges and other hydronic accessories for all waterside piping systems.
8. Provide insulation for piping, ductwork and equipment.
9. Provide direct digital control system including all controls, components and control wiring.
10. Provide complete balancing and testing of all air and water systems.
11. Provide HVAC commissioning.
12. Provide condensate drain piping.
13. Provide energy recovery ventilators.
14. Provide pressure independent control valves for all equipment and terminal units connected to waterside systems
15. Provide water source heat pump energy recovery ventilators with roof curb.
16. Provide supply, return, and exhaust air ductwork.
17. Provide sheet metal that is within the tolerance of the gauges for airside systems.
18. Provide ductwork leakage testing.
19. Provide piping pressure testing.
20. Provide strainers at the inlet of control valves and wherever needed.
21. Provide air vents, unions, strainers, thermometers and gauges for all piping systems.
22. Provide all steel supports, vibration isolators, hangers and inertia bases for all equipment, ductwork and piping.
23. Provide relief valves and piping for pressure vessels such as water source heat pumps.
24. Provide fire and smoke dampers where indicated or needed.
25. Provide all fire-stopping for your work.
26. Provide startup on all equipment by factory authorized personnel.
27. Provide all software and integration cards on all equipment with factory controls.
28. Provide airflow and waterflow measurement stations.
29. Provide 15% and 35% inhibited propylene glycol solution.

B. The following items of work related to HVAC will be performed by others as follows:

1. The General Contractor shall provide all foundations and pads for equipment, paint all piping in finished areas, provide all base flashing on roof, build in all sleeves, unless otherwise noted.
2. The Plumbing Contractor shall provide gas outlets for heating and air conditioning equipment for final connection to equipment by the HVAC Contractor.
3. The Electrical Contractor shall do all power wiring for HVAC equipment.

1.5 WORK AS A SUBCONTRACTOR

A. When the HVAC work is subcontracted, the exact scope of work may be limited or added to at the discretion of the General Contractor/Construction Manager. A subcontractor shall, therefore, verify the extent of his work with the General Contractor/Construction Manager.

1.6 RELATED WORK SPECIFIED ELSEWHERE

The following related work items are included in separate divisions and Sections as follows:

A. General Requirements, Division 01.

B. Roof – Division 07.

C. Basic Plumbing Requirements – Division 22.

D. Fire Protection General Requirements – Division 21.

E. Electrical – Division 26.

PART 2 - PRODUCTS

A. As specified in the following related sections.

PART 3 - EXECUTION

A. All HVAC systems shall be complete and fully operational.

B. It is the intent of the Drawings and Specifications and the contractor responsibility is to provide a complete code compliant workable system ready for the Owner’s operation. Any item not specifically shown on the Drawings or called for in the Specifications, but normally required to conform to the intent, are to be considered a part of the Contract.

END OF SECTION 23 00 00

SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 STIPULATIONS

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

1.2 EXECUTION OF THE WORK

A. These specifications call out certain duties of the HVAC Contractor and any Subcontractors. They are not intended as a material list of items required by the Contract. Any reference in these specifications and on the accompanying drawings to the Contractor, Mechanical Contractor, ATC Contractor, Mechanical HVAC Subcontractor, Subcontractor or abbreviation "M.C.", shall be construed to mean the Contractor responsible for all mechanical construction (Division 23) work for this project.

B. This division of the specifications covers the HVAC systems of the project. It includes work performed by the mechanical trades as well as trades not normally considered as mechanical trades.

C. Provide all items and work indicated on the Drawings and all items and work called for in this division of the specifications in accordance with the conditions of Contract (Division 01 General Requirements Documents). This includes all incidentals, equipment, appliances services, hoisting, scaffolding, supports, tools supervision, labor consumable items, fees licenses, etc., necessary to provide complete systems. Perform start-up and checkout on each item and system to provide fully operable systems.

D. Comply with all provisions of the Contract Documents including the General Conditions, and Division 01 General Requirements of the specifications.

E. Certain terms such as "shall, provide, install, complete, start-up" are not used in some parts of these specifications. This does not indicate that the items shall be less than completely installed or that systems shall be less than complete.

F. Examine and compare the HVAC Drawings with these specifications, and report any discrepancies between them to the Architect/Engineer and obtain from him written instructions for changes necessary in the work. At time of bid the most stringent requirements must be included in said bid.

G. Examine and compare the HVAC Drawings and Specifications with the Drawings and Specifications of other trades, and report any discrepancies between them to the Architect/Engineer and obtain from him written instructions for changes necessary in the work. At time of bid, the most stringent requirements must be included in said bid.

H. Install and coordinate the HVAC work in cooperation with other trades installing interrelated work. Before installation, make proper provisions to avoid interferences in a manner approved by the Architect/Engineer. All changes required in the work of the Contractor, caused by his neglect to do so, shall be made by him at his own expense.

I. It is the intent of the Drawings and Specifications to provide a complete code compliant workable system ready for the Owner's operation. Any item not specifically shown on the Drawings or called for in the Specifications, but normally required to conform to the intent, are to be considered a part of the Contract.

J. These specifications are basically equipment, installation, and performance Specifications. Some installation details are indicated on the Drawings. Where these differ from the Specifications, apply the more stringent at time of bid. Upon award of bid, contact Architect/Engineer for definite instructions.

K. All materials furnished by the Contractor shall be new and unused (temporary services are excluded) and free from defects.

L. All products and materials shall be new, clean, free of defects and free of damage and corrosion.

M. The exclusion from, or limitation in, the symbolism used on the Drawings or the language used in the Specifications for HVAC work shall not be interpreted as a reason for omitting the accessories necessary to complete any required system or item of equipment.

N. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.

O. All items of equipment or material shall be the product of one manufacturer throughout. Multiple manufacturers will not be permitted.

P. Receive, inspect, store and install Owner-furnished equipment where Owner furnished equipment is supplied.

1.3 COORDINATION OF THE WORK

A. Certain materials will be provided by other trades. Examine the Contract Documents to ascertain these requirements.

B. Carefully check space requirements with other trades and the physical confines of the area to insure that all material can be installed in the spaces allotted thereto including finished suspended ceilings and the spaces within the existing building. Make modifications thereto as required and approved.

C. No items foreign to the electrical system shall be run in the dedicated space of the electrical equipment. Dedicated space shall be defined as the width and depth of the equipment from the floor to the bottom of the structural ceiling. Foreign systems include but are not limited to ductwork, piping, sprinklers, drip trays, etc. Contractor shall be responsible to coordinate the locations of the dedicated spaces with electrical and other trades as required.

D. Transmit to other trades all information required for work to be provided under their respective Sections in ample time for installation.

E. Wherever work interconnects with work of other trades, coordinate with other trades to insure that all trades have the information necessary so that they may properly install all the necessary connections and equipment. Identify all items of work that require access so that the ceiling trade will know where to install access doors and panels.

F. Due to the type of installation, a fixed sequence of operation is required to properly install the complete systems. Coordinate, project and schedule work with other trades in accordance with the construction sequence.

G. The locations of piping, control panels, diffusers and other equipment indicated on the Drawings are approximately correct, but they are understood to be subject to such revision as may be found necessary or desirable at the time the work is installed in consequence of increase or reduction of the number of outlets, or in order to meet field conditions or to coordinate with modular requirements of ceilings, or to simplify the work, or for other legitimate causes.

H. Exercise particular caution with reference to the location of panels, diffuser, grilles, sensors, thermostat, switches, etc., and have precise and definite locations approved by the Architect/Engineer before proceeding with the installation.

I. The Drawings show only the general run of duct/piping and approximate location of outlets/termination. Any significant changes in location of routing, necessary in order to meet field conditions shall be brought to the immediate attention of the Architect/Engineer and receive his approval before such alterations are made. All such modifications shall be made without additional cost to the Owner.

J. Obtain from the Architect/Engineer in the field, the location of such outlets or equipment not definitively located on the Drawings.

K. Wherever the work is of sufficient complexity, prepare additional Detail Drawings to scale similar to that of the bidding Drawings, prepared on tracing medium of the same size as Contract Drawings. With these layouts, coordinate the work with the work of other trades. Such detailed work shall be clearly identified on the Drawings as to the area to which it applies. Submit for review Drawings clearly showing the work and its relation to the work of other trades before commencing shop fabrication or erection in the field.

L. Contractor shall furnish services of an experienced Superintendent, who shall be in constant charge of all work, and who shall coordinate his work with the work of other trades. No work shall be installed before coordinating with other trades.

M. Coordinate with contractors for work under other Divisions of this specification for all work necessary to accomplish this contractor’s work.

N. Where service connections are required, to equipment provided by the Owner or by other trades, this Contractor shall verify the exact requirements for these connections prior to ordering any materials or laying out any work. Where there is a discrepancy between the equipment being furnished and that shown on the Contract Drawings, the Contractor shall notify the

Architect/Engineer for direction. Failure to comply with this coordination shall not constitute a reason for extra monies for equipment ordered or installed. Restocking charges will not be paid.

1.4 RELATED DOCUMENTS

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

1.5 SUMMARY

A. This section includes the general requirements that apply to the Mechanical and HVAC Contractor. Fire Protection and the Controls Contractor or Sub-Contractor.

B. The following work is specified under other Divisions, unless otherwise noted or specified hereinafter:

1. Painting except as herein specified shall be by the General Contractor under Division 09.
2. Site Work, Divisions 31, 32 and 33.
3. Concrete, Division 03.
4. Roof, Division 07.
5. Plumbing, Division 22.
6. Electrical, Division 26.
7. Installation of starters, contactors, thermal overload switches and remote push buttons, and connection of power wiring to motors, Division 26.

1.6 INTENT

A. Requirements specified herein shall govern applicable portions of Heating, Ventilation and Air Conditioning.

B. It is the intent of this specification and accompanying drawings to describe and indicate the general manufacture, erection and installation of the equipment and connection to same specified herein and shown on the drawings. It is not intended that the specifications and drawings describe and indicate each piece of equipment required for installation, for where items are intended or required for satisfactory installation and are considered to be the accepted practice of the trade, they shall be considered to be both specified and indicated. Drawings are diagrammatic in nature; for piping systems; water piping is tapped off the bottom of the pipe and steam and steam condensate piping is tapped off the top of the pipe; provide all tees, elbows and swing joints as required for hookup to coils or branch piping as required for this work whether they are indicated on the drawings or not. For ductwork systems, provide offsets at interference locations and/or where changes in ceiling heights require such offsets; offsets shall be smooth as possible and without the need for hard elbows; offsets shall minimize the elbow angle required which shall result in minimal static pressure gradients into the system.

C. It shall be understood that the Contractor as hereinafter mentioned shall be the Mechanical Contractor unless specifically noted otherwise.

D. The Contractor shall furnish all plant, labor and material necessary for the complete and satisfactory installation of all Mechanical work for this contract.

E. The Contractor shall assume the entire responsibility for the materials, workmanship and satisfactory operation of the various mechanical systems, and other work as specified herein and/or as shown on the drawings.

F. The Contractor shall schedule and coordinate all work in close cooperation with all trades working on this project.

1.7 DEFINITIONS

A. Following definition of terms and expressions used in this section are in addition to listing given in Supplementary Conditions:

1. "Provide" shall mean "furnish and install" unless otherwise indicated.
2. "Herein" shall mean the contents of a particular section where this term appears.
3. "Indicated" shall mean "Indicated on contract drawings".
4. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
5. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
6. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
7. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
8. 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.
9. The following are industry abbreviations for plastic materials:
    a. ABS: Acrylonitrile-butadiene-styrene plastic
    b. CPVC: Chlorinated polyvinyl chloride plastic
    c. NP: Nylon plastic
    d. PE: Polyethylene plastic
    e. PVC: Polyvinyl chloride plastic
10. The following are industry abbreviations for rubber materials:
    a. CR: Chlorosulfonated polyethylene synthetic rubber
    b. EPDM: Ethylene propylene dieneterpolymer rubber
11. For additional abbreviations see the Abbreviations and Symbols Drawings.

1.8 CONTRACTOR'S RESPONSIBILITY

A. The Contractor shall be responsible for establishing grades and elevations, and checking of all interferences, and shall verify all dimensions and locations in the field.

B. Contract drawings for mechanical work are in part diagrammatic, intended to convey the scope of work and indicate general arrangement of equipment, ducts, piping and approximate sizes and locations of equipment outlets. Mechanical trades shall follow these drawings in layout of their work, consult general construction, structural and electrical drawings to familiarize themselves with all conditions affecting their work, and shall verify spaces in which their work will be installed.

C. The Contractor shall verify with the A/E before bidding any item of piping or piping arrangement which may be incomplete, incorrect or indefinite. After contract is let, the A/E's decision shall be final.

D. All trades shall cooperate and confer with each other as to locations of their materials and equipment before erecting work, so as to avoid interference as much as possible, and in such a manner that will in no way retard progress of construction. In instances where interferences develop, the contractor shall relocate the work as required by the A/E regardless of which work was installed first.

E. Where job conditions require reasonable changes to indicate locations and arrangement, make such changes without extra cost to Owner. This is not to be construed to permit redesigning of the various systems.

F. Additional and supplementary drawings may, from time to time, be furnished, and the same, when made, are to constitute a part of the original contract. These drawings will be made to clarify the contract drawings and will not depart materially therefrom.

G. The A/E specifically reserves the right, up to the time of roughing-in, to exactly define the position of the equipment to be installed and connected to and arrangement of these connections.

H. Special attention is called to the contract drawings and specifications involving general construction, electrical work and details thereon. Bidders are notified to carefully scrutinize these documents for the details affecting the performance of the mechanical trades.

1.9 SCHEDULE OF WORK

A. The Contractor shall schedule all of his work to conform to the Job Progress Schedule as submitted by the General Contractor or Construction Manager, and approved by the A/E.

1.10 PREMIUM TIME WORK

A. The following work shall be performed at night or weekends other than holiday weekends, as directed and coordinated with the Owner:

1. Tie connections to all existing systems.
2. All work in the existing building finished space.

1.11 PROGRESS OF WORK

A. The Contractor shall order the progress of his work so as to conform to the progress of the work of other trades and shall complete the entire installation as soon as the conditions of the building will permit. Any cost resulting from the defective or ill-timed work performed under this section shall be borne by the Contractor.

1.12 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver, store, protect and handle all products and materials in a manner which will protect them from damage, weather and entry of debris. If items are damaged, do not install, but take immediate steps to obtain replacement or repair. Any such repairs shall be subject to review and acceptance of the Architect/Engineer.

B. Delivery of Materials: Delivery materials in manufacturer's unopened container fully identified with manufacturer's name, trade name, type, class, grade, size and color.

C. Storage of Materials, Equipment and Fixtures: Store materials suitably sheltered from the elements, but readily accessibly for inspection by the Architect/Engineer until installed. Store all items, susceptible to moisture damage, in dry, heated spaces.

D. Protect materials and equipment according to the manufacturer’s instruction. Protection shall include damage due to fire, water, rust, oxidation, sunlight (for UV sensitive materials), breakage of UV lights, etc.

E. Following is in addition to Protection of Work and Property, General Requirements:

1. Responsibility for care and protection of mechanical work rests with the Contractor until it has been tested and accepted.
2. After delivery, before, during and after installation, protect equipment and materials against theft, injury and damage from all causes.
3. Protective covers, skids, plugs, caps and coating shall be provided to protect equipment materials from damage during construction.
4. All equipment and material shall be stored under cover and off the ground.
5. For outdoor storage, protective covers of sheet plastic shall be provided. Covers shall be of gauge required for the area involved and shall be reinforced to withstand wind, rain, sleet and snow. Equipment and material shall be set on skids or platforms of sufficient height to avoid deterioration from spattering and ground water.
6. Plug open ends of pipes when work is stopped to prevent debris from entering the pipes.

7. Open ends of duct work shall be closed when work is stopped with temporary closures of sheet plastic taped in place on horizontal ducts and sheet metal caps with drip overhangs for ducts opening upward.
8. Air handling system shall not be operated during the construction period.
9. Coat polished or plated metal parts with Vaseline immediately after installation.

F. The Contractor shall receive, properly house, handle, hoist, and deliver to proper location, equipment and other materials required for the contract.

G. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Architect/Engineer and at no additional cost to the Owner.

1.13 INTERFERENCE WITH THE OWNER'S NORMAL OPERATION

A. All work shall be performed in such a manner as not to interfere with the normal work operations in adjacent spaces or buildings.

B. In no way shall the Contractor:

1. Block or restrict the means of egress for adjacent spaces.
2. Decrease the fire rating of walls, partitions, ceilings, doors or combination thereof of adjacent spaces or of means of egress.
3. Interrupt safety systems or in any way adversely affect the safety of people or materials in adjacent spaces.

C. The Contractor shall provide acoustical isolation of the work area via temporary doors, partitions, etc., adequate to allow normal work functions.

D. The Contractor shall provide exhaust fans, dust proof temporary partitions and any containment measure required to prevent dirt, dust, or fumes from reaching adjacent work spaces.

E. All personal traffic and material delivery shall be routed so as to absolutely minimize travel through adjacent work area.

1.14 VISIT TO SITE

A. The Contractor shall visit the site and thoroughly acquaint himself with all existing conditions relative to type and source of service available. He shall verify location and extent of these services and consider routing, interferences and excavation required by the contract and any and all other difficulties that may be encountered.

B. Submission of a proposal shall be construed as evidence that such an examination has been made.

C. Failure to visit the site shall not constitute sufficient reason to warrant claims for extra monies for difficulties not apparent in the contract documents.

1.15 MANNING THE PROJECT

A. The Contractor shall, upon initiation of construction, keep a suitable force of men on the site at all times in order to lace all sleeves, inserts, outlet boxes, fixtures and provide all other openings as are required for the satisfactory installation of equipment.

1.16 FEES AND PERMITS

A. The Contractor shall secure all permits and pay all fees, required by local and state governing bodies, necessary to complete his phase of the construction. Failure to investigate all applicable payments before the bid submission shall not constitute grounds for additional monies from the Owner. The Owner shall be furnished with all certificates of approval.

B. The Contractor shall provide insurance and bonding as required by the Building Owner or as stated in the General Conditions.

1.17 CODES AND STANDARDS

A. The design, construction and installation of all materials and equipment shall be in compliance with the latest edition of all national, state and local codes or standards.

B. The codes and standards referred to are minimum standards. Where the requirements of these specifications and the accompanying drawings exceed those of the codes and standards, the drawings and specifications shall be followed.

1.18 BASIS OF DESIGN

A. The layout is based upon the use of particular items of equipment, identified by manufacturer's make and model number. Dimensions, arrangements and service connections required for these particular items have been considered in making the layout. The contractor may use the equipment of any manufacturer whose name is approved for substitution on that item of equipment after he had ascertained that all provisions of MATERIAL SUBSTITUTIONS will be complied with and that all required service connections will be made at no additional cost to the Owner.

B. Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise, or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding**.

C. Except where dimensions are shown, the drawings are diagrammatic and shall not be scaled. Exact location of fixtures, apparatus, duct work and piping shall be determined by dimensions on the site. Contractor shall refer to architectural plans and details for exact dimensions.

D. The drawings indicate the locations of apparatus, fixtures, ductwork, and piping shall be followed as closely as possible. If before the installation it is found necessary to change the location to accommodate conditions at the building, such changes shall be made at no additional cost to the Owner, and as approved by the Architect/Engineer.

E. Equipment requiring operation, service or maintenance during the life of the system shall be made easily accessible.

F. Ductwork or piping shall not be run within 48" of switchboards, panelboards or motor control centers.

G. No piping, ductwork to other HVAC items shall be run in the dedicated equipment space as defined in the N.E.C. (NFPA 70). The dedicated equipment space is the space equal to the width and depth of the equipment and extending from the floor to a height of 6ft. Refer to the National Electrical Code section 110.26 (E) for further information. No piping, ducts, leak protection apparatus, or other equipment foreign to the electrical installation shall be located in this zone. It is this contractor’s responsibility to coordinate with the electrical contractor for all phases of this project.

H. Use of open-flame devices in work shall be accompanied by fire extinguishing apparatus within 25 feet of work location. All work shall be done in accordance with the general construction requirements and fire watch procedures.

1.19 QUALITY OF MATERIALS

A. Where a specific model and manufacturer of equipment is specified, the Contractor shall provide what is specified without substitution. Where specified as "or approved equal", the Contractor may substitute equipment except that the burden is upon the Bidder to prove such equality. If the Bidder elects to prove such equality, he must request the Architect's approval in writing to substitute such item for the specified item, stating the cost difference involved with supporting data, and samples, if required, to permit a fair evaluation of the proposed substitute with respect to quality, serviceability, warranty and cost.

B. Where a specific model of equipment is specified along with an approval equal manufacturer, no substitution will be allowed. The Contractor shall submit one of the manufacturers listed.

C. Final approval of competitive equipment is reserved by the Engineer when, in the Engineer's opinion, the equipment does not correspond to that specified.

1.20 MATERIAL SUBSTITUTIONS

A. Material substitutions shall be allowed only where "or equivalent" is stated.

B. Material substitution submittals shall, include complete description of the proposed substitute, the name of the material or equipment for which it is to be substituted, drawings, cuts, performance, test data and evidence that the proposed manufacturer or his established representative maintains a qualified service organization including spare parts and is available for competent service on short notice.

C. Each bidder by submitting his bid represents that the proposal of such article, device, product, material, fixture, form or type of construction by name, make, catalog number of manufacturer which varies with the equipment specified shall be incorporated into the project without claims against the Owner for additional cost. The bidder shall be responsible for all additional costs incurred by others due to the substitutions.

D. The Architect/Engineer shall have the final approval of all submitted substitutions.

E. Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise, or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding**.

1.21 SUBMITTALS

A. Product Data, Shop Drawings: Submit for approval by the authority having jurisdiction and the Owner's insurance underwriter.

B. Product Shop Drawing Submittal List:

1. Within thirty (30) days after date of execution of the Owner/Contractor Agreement, submit for review and acceptance, a list of all material and equipment manufacturers whose products are proposed, as well as names of all subcontractors whom this trade proposes to employ.
2. Any requests for substitutions of equipment or materials must be submitted and returned prior to submitting the Submittal List. Only specified or accepted manufacturers or suppliers shall appear on the Submittal List.
3. The complete Submittal List must be reviewed and accepted by the Architect/Engineer prior to submittal of Shop Drawings. No Shop Drawings will be processed without an accepted Submittal List.
4. The Submittal List shall include all material, systems, and equipment specified herein.

C. Approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage or installation of equipment or material which has not had prior approval will not be permitted at the job site.

D. All submittals shall bear a stamp or notation indicating that the Contractor has reviewed and approved the submittals.

E. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings and other data necessary to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and shall clearly identify equipment being submitted.

F. Submittals shall be marked to show specification reference including the section and paragraph numbers.

G. Submit each section separately and include the following:

1. Information which confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, pictures, nameplate data and test reports as required.
2. Submittals on all pumps and fans shall be complete with performance curves marked with the design points.
3. Submittals on electrical equipment shall be complete with all power and control wiring diagrams.
4. Vibration isolators shall include operating weight and load distribution at each mounting point.

H. The Contractor agrees that failure of manufacturer's submittal to conform to the above will result in a manufacturer's disqualification on this project.

I. Submit samples as directed of items called for in the specifications; samples of the materials which the manufacturer will actually ship shall be submitted for approval after award of contract and properly labeled on this project.

1.22 COORDINATION DRAWINGS

A. Detailed layout shop drawings on all systems as required in Division 01 – Project Coordination, Division 21, 22, 23, and 26, must be coordinated with field erection drawings for Architectural, HVAC, Plumbing, Fire Protection, and Electrical Systems by the respective contractors.

B. Prepare coordination drawings for all areas by building, floor area and/or phase, of the project. Close attention should be implemented where limited space availability necessitates maximum utilization of space for efficient installation of different components.

C. Mechanical, Electrical and Plumbing Prime Contractors are responsible to prepare coordination drawings to a Scale of ¼” = 1’-0” or larger; detailing major elements, components, and systems of mechanical and electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including but not limited to the following:

1. Proposed locations of ductwork, piping, conduit, equipment, and materials.
2. Clearances for installing and maintaining insulation.
3. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
4. Equipment connection and support details.
5. Exterior wall and foundation penetrations.
6. Fire rated wall, floor, ceiling, and roof penetrations.
7. Sizes and location of required concrete pads and bases.
8. Valve stem movement.
9. Sleeves.

D. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations. Clearly define relationships between sleeves, piping, ductwork, conduit, ceiling grid, lighting, fire sprinkler, HVAC equipment and other mechanical, plumbing, and electrical equipment with other components of the building such as beams, columns, ceilings, and walls.

E. Prepare reflected ceiling plans to coordinate and integrate installations of air outlets and inlets, light fixtures, communication systems components, sprinkler, and other ceiling mounted items.

F. Resolve conflicts between trades, prepare composite coordination drawings and obtain signatures from all affected Prime Contractors on original composite drawings. Submit coordination drawings to the Architect/Engineer and Construction Manager for approval.

G. Mechanical, Electrical and Plumbing Prime Contractors are to first submit their respective shop drawings for approval, to the Architect/Engineer, in order to make any necessary changes prior to going through the coordination process.

H. Coordination drawings to be signed off by affected Contractors within 45 days of Notice to Proceed. A Coordination drawing timeline schedule shall be developed and tracked.

I. The coordination drawings shall be coordinated with the construction and phasing schedule.

J. The routing process will begin with the HVAC Contractor who shall take the lead in the coordination of their work with all affected trades.

K. The HVAC Contractor shall prepare CAD drawings to be used as the basis for coordination drawings in all areas or as determined by the Construction Manager (Scale: ¼” = 1’-0” or larger). These drawings shall be completed in digital format. All architectural features shall be accounted for in preparation of this drawing; i.e., permanent, casework, interior columns, partitions, finish ceiling and height, lighting and roof elevations, etc. The HVAC Contractor will provide CAD files and drawings showing all of the approved ductwork. HVAC Contractor is to locate all piping with orange lines. Forward drawings to the Plumbing Contractor.

L. The Plumbing Contractor is to locate the plumbing lines with blue lines and sprinkler lines and head locations with red lines, and resolve all conflicts and determine locations and elevations, and forward drawing to the Electrical Contractor.

M. The Electrical Contractor to indicate all lighting fixtures, panels with associated clearances, duct banks, bus duct, conduit racks and all individual conduits 1 ½” and larger in with green lines, and resolve all conflicts and determine locations and elevations and forward to the General Construction Contractor.

N. The General Construction Contractor will have the last coordination review. Provide overlaid coordination drawings for all General Construction work and resolve all conflicts. All architectural features shall be detailed clearly, i.e. permanent casework, interior columns, partitions, finish ceiling and roof elevations, etc. Provide a ceiling layout detailed coordination drawing showing ceilings, lights, diffusers, etc.

O. Contractors to provide underground coordination drawings for all underground utilities; show exact location of piping stub ups, floor drains, etc. as required.

P. Prime Contractors shall be responsible for all costs associated with creating CAD files.

Q. All coordination meetings will be held in the Construction Manager's field office or as required by the Architect/Engineer. As each coordination drawing is completed, Contractors are to meet with the Construction Manager to review and resolve all conflicts on the coordination drawings. Contractors are required to distribute shop drawings, cut sheets and submittals to other Prime Contractors where appropriate. Approved coordination drawings will also be available for reviewing at the Construction Managers field office.

R. All Contractors shall provide a hard copy of the coordination drawings for review by the Architect/Engineer.

S. Once complete and signed off, the HVAC, Plumbing and Electrical Contractors will submit dimensioned wall and slab penetration drawings and housekeeping pad drawings to the appropriate parties.

T. If the coordination drawing process is not complete, Mechanical, Electrical and Plumbing Contractors will provide wall penetration drawings to the General Construction Contractor no later than five (5) days prior to wall erection.

U. All Prime Contractors must install the work in accordance with the coordinated drawings at no additional cost to the Owner. No additional compensation will be made for extra ductwork offsets, piping and/or conduit or retrofit work due to improper component location, or lack of Contractor(s) coordination.

V. All Prime Contractors shall take special care in verifying with the Electrical Contractor that the equipment matches the characteristics of the power being supplied. The Electrical Contractor is similarly bound.

W. The Mechanical, Electrical and Plumbing Drawings are schematic in nature and are not intended to show every offset and detail. The Mechanical, Electrical and Plumbing Contractors will make adequate provisions in their bid to accommodate the actual conditions, provide all required ductwork, piping and conduit offsets per the coordination drawings, without additional cost to the Owner.

X. The Mechanical, Electrical and Plumbing Contractors shall hang streamers from all above ceiling equipment that will require access. This is in addition to any specification requirements for tags, labels, etc. Shop drawings should also highlight these areas for Architect/Engineer's review. In addition, the Contractors shall notify the Construction Manager and Architect/Engineer of all areas where equipment maintenance access is difficult. Coordinate architecturally placed access doors with points of mechanical/electrical systems requiring that access.

Y. Specific Requirements – Required Information to be provided on Coordination Drawings:

1. General Construction/Structural Work Information including but not limited to:

   a. Openings and sleeve locations required in slabs, walls, beams, and other structural elements, including required openings not indicated on the Contract Documents.
   b. Slab edge locations

c. Embed locations, as described above. Note embedded steel angles at edges of sump and sewage ejector pits, to accept basin covers.
d. Wall and chase spaces for housing HVAC, Plumbing, or Electrical items.
e. Access doors in coordination with the respective contractor systems.
f. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

2. HVAC Work Information including but not limited to:

a. Sizes and bottom elevations of rectangular ductwork, including angle bracing, flanges, and support systems.
b. Sizes and centerline elevations of round ductwork, piping and conduit runs
c. Acoustical lining in ductwork.
d. Identification of ductwork pressure class.
e. Dimensions of major components, such as dampers, valves, diffusers, registers, cleanouts, coils, VAV boxes, HVAC equipment, and electrical distribution equipment.
f. Fire-rated enclosures around ductwork.
g. Access panels required.
h. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

3. Plumbing and Fire Protection Information including, but not limited to:

a. Sizes and centerline elevations of piping runs.
b. Locations of plumbing valves, equipment, and fixtures.
c. Locations of standpipes, floor control assemblies, fire hose valves, mains, piping, branch lines, pipe drops, sprinkler heads, fire pumps/controllers, and jockey pumps.
d. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

4. Electrical Work Information including, but not limited to:

a. Runs of vertical and horizontal conduit, 1 ¼” diameter and larger
b. Light fixture locations
c. Exit light locations
d. Smoke detector and other fire alarm locations
e. Panelboards, switchboards, switchgear, transformers, busways, generators and motor control center, exit signs, and emergency battery pack locations.
f. Locations of pull boxes and junction boxes, dimensioned from column centerlines
g. Access panels required.
h. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

5. Ceiling Systems and Plenum Space Information including, but not limited to:

a. For HVAC, Plumbing, Fire Protection, Fire Alarm, Electrical, Controls and Telecommunications Work penetrating acoustical ceilings, show locations of each item (including sprinkler heads, diffusers, grilles, access doors, light fixtures, smoke detectors exit signs, speakers, and other visible ceiling mounted devices) relative to the acoustical ceiling grid.

b. Locate components within ceiling plenums to accommodate layout of light fixtures indicated on Drawings. Clearly indicate areas of conflict between light fixtures and other components on Coordination drawings.

c. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

d. Materials within plenums shall be non-combustible or shall be listed and labeled as having a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84 or UL 723. All materials located in plenums shall conform to International Mechanical Code.

Z. The Sheet Metal Contractor shall prepare his work on reproducibles and submit 1/4" scale CAD drawings of the sheet metal duct field erection shop drawings for the coordination procedures, and each Contractor will supply the necessary qualified personnel for these procedures which will be conducted by the General Contractor. The HVAC, Plumbing and Fire Suppression work to the drawings where conflicts are noted and achieve solutions to any conflicts that may exist.

AA. The General Contractor will be required to signify his acceptance of the results of the coordination procedures by signing and dating the master coordination print.

BB. Each Contractor will be required to correct his field erection drawing(s) used as a basis for the coordination procedures to complement the results of the procedures prior to submitting same for approval. No field erection shop drawings will be accepted for approval without having been coordinated.

CC. As part of the coordination procedures, applicable "Approval" or "Approved as Noted" copies of other trades' shop drawings will be transmitted to the Contractor. It will be each Contractor's responsibility to check these shop drawings to ascertain what effect, if any, these shop drawings have on that portion of the work under his direct responsibility. Each contractor will advise the General Contractor within forty-eight (48) hours of receipt of the shop drawings, in writing, indicating receipt of same and whether or not they have any effect on the work of his contract.

1.23 ELECTRICAL

A. Power Wiring

1. For the purpose of this specification, power wiring shall be defined as follows:

a. All wiring from the power source panelboards (or switchboard) to the disconnect switch to the equipment, and final connection to the equipment.

b. All power wiring to transformers serving VAV/CV boxes.

c. All wiring to control panels as indicated in the Electrical and Mechanical Contract Documents. (All control panels not indicated on the Electrical Contract Documents as receiving power shall do so by jumpers from other control panels, this wiring shall be considered control wiring as defined below).

2. All power wiring from the power source to the above noted switches and wiring from these switches to the equipment, including final connection to same, shall be provided under Division 26, Electrical.

B. Control Wiring

1. All other wiring required, whether line voltage or low voltage, internal or external to provide for the operation of the equipment shall be considered as control wiring. This shall include power wiring from transformers serving VAV/CV boxes and dampers at exhaust fans; wire to damper and fan end switch to starter.
2. All control wiring throughout the building, including wiring installed at piping, in ductwork, or as specified shall be provided under this Division.

C. The Contractor shall furnish all motors, mounts, motor starters and remote mounted push-button controls for all electrically operated equipment furnished as part of the contract. The Contractor shall furnish all safety disconnects where described hereinafter. The Contractor shall furnish all speed control switches for all multi-speed motors. All motors shall have copper windings. (Aluminum windings will not be acceptable).

D. This Contractor is completely responsible for the coordination with all other trades as to the correct voltage for all equipment requiring power. Equipment and or changes required to meet the project voltages will be the responsibility of this contractor.

E. All push-button switches and starters shall be mounted under Division 26, Electrical.

F. The Contractor shall provide all controls and control devices, all mounting for controls and all other electrical devices as specified and necessary for the complete installation and satisfactory operation of all electrically operated controls furnished under this Division.

G. All locally mounted starters shall be furnished under Division 23, except as noted below. Where indicated hereinafter, starters shall be furnished as an integral part of equipment. Starters furnished in motor control centers shall be provided in Division 26, Electrical (refer to Electrical Drawings). Control of starters in motor control centers feeding mechanical equipment shall be provided under Division 23.

H. Starting equipment of each motor shall be of the proper voltage and HP rated for the motor it is to serve. All starters shall be of the enclosed type; NEMA Type 1, for general-purpose enclosures; NEMA Type 4 for watertight enclosures, and NEMA Type 12 for the dust-tight enclosures. Location of motor shall determine type of enclosure to be used.

I. Manual motor starters for single-phase motors shall be one or two poles as required, consisting of a snap switch combined with a thermal overload device. It shall be impossible for the switch to be held in a closed position under a sustained motor overload. For resetting the overload mechanism, the switch lever shall be of a design where it has to be moved to the "off" position. Starter shall be enclosed in type of enclosure for area in which it is to be used.

J. Magnetic starters for 3-phase motors shall be furnished with 110 volt holding coils, 120 volt fused transformers, normally open and normally closed auxiliary contact and overload relay heater elements in all three phases. Provide hand/off/auto selector switch along with running status lights and external reset button.

K. Locate starters and associated starter controls in accessible locations wherever possible. Location of starters for roof mounted exhaust fans and mechanical equipment above ceilings shall be located at accessible locations above ceiling. Locations shall be coordinated with furniture and equipment layouts for the optimum accessible location for installation and maintenance means.

L. The Contractor shall be completely responsible for the coordination of automatic temperature control system with control interlocks between various items of mechanical equipment.

1.24 SCAFFOLDING

A. The Contractor shall furnish and install scaffolding, ladders and runways required in connection with his work.

1.25 TEMPORARY OPENINGS

A. Temporary openings not indicated, which may be required for purpose of bringing equipment into building, shall be as approved. General Contractor will perform work of providing and maintaining openings, and of restoring structure; but Contractor for whom temporary openings are provided shall bear costs thereof, and for restoring structure. Ample notice shall be given of size and location of such openings by Contractor requiring same.

B. Holes provided in General Construction work to permit installation of lines for temporary mechanical services will, after removal of such lines, be patched as specified under Division 01.

1.26 TEMPORARY SERVICE

A. Temporary services are specified under Division 01, “General Requirements”.

1.27 CUTTING AND PATCHING

A. The Contractor shall provide all floor and wall cuts as required for ductwork and piping penetrations of existing construction.

B. No cutting of bearing walls, beams, etc., shall be done without the approval of the Architect. All patching and finishing, etc., shall match the surroundings. All cutting and patching shall be done by workmen skilled in the trades and in the employ of the General Contractor for the project. All cutting shall be done with saw type edges to give a neat and workmanlike appearance. All pipe holes shall be core drilled unless specified otherwise.

C. Should it be necessary to do any cutting and patching due to the failure of this Contractor to give proper information to the General Contractor, it shall be done at the expense of the Mechanical Contractor.

1.28 PAINTING AND FINISHING

A. Except as specified herein, the finished painting of Mechanical Work within the building and on the roof shall be as specified under Division 09.

B. All mechanical equipment shall have a factory-applied prime and finish coat of paint. Galvanized surfaces shall be considered as finished surfaces for equipment rooms and items concealed from view. Plastic products shall be acceptable without a finish coat of paint. All items of equipment marred or rusted, even though factory finished, shall be repainted; steel angles and steel supports for ductwork, piping or miscellaneous equipment shall have a prime coat of paint before installation.

C. General Contractor to paint all exposed piping, ductwork, equipment, and trim that does not have a factory applied finish. Refer to Division 09 "Painting" for paint materials, surface preparation and application of paint. Paint shall be semi-gloss, acrylic-enamel paint. Coat components with two (2) coats of finish paint over two (2) coats of rust inhibitive metal primer or approved equivalent based on component type.

1.29 CONCRETE WORK

A. Concrete work shall be in accordance with Division 03.

1.30 SUSPENSION SUPPORT FOR DUCTS, PIPES, EQUIPMENT

A. All pipes, ducts, and equipment that are suspended shall be connected directly to the building steel. Where hangers are required between building steel points, supplementary steel members shall be added by the Contractor as required to adequately support the load.

B. Pipes and ducts shall not be supported from other pipes, ducts, or equipment.

C. Hangers from joists shall be attached at the panel points. Pipes and ducts with weights of 50 pound per foot (total for single or multiple runs) routed parallel with bar joists shall be supported from a minimum of 3 joists at each hanger point (channel members between joists).

1.31 ACCESS PANELS – BUILDING

A. Duct access panels, access plates, damper operators, fan cleanouts and valves located concealed in walls or above ceilings, and are otherwise inaccessible shall be furnished with an access panel for each location. A hinged inconspicuous type access panel complete with frame, of such size and so located as to provide proper access for service and maintenance.

B. The minimum size of each access panel shall be 18” x 18” unless physical restraints require a smaller door.

C. Where such equipment is located above removable concealed spline push up type acoustical tile or metal pan ceilings, it shall be considered as accessible if the acoustical material is arranged for access to the space above the ceilings.

D. Access panels shall be Milcor “DW”, or equal, for drywall locations and Milcor “K”, or equal, elsewhere.

E. Panels and frames shall be prime painted.

F. Panels shall be furnished under this Division and installed under another Division of the Specification.

G. Panel material shall be steel except that construction shall be all aluminum in bathroom applications.

H. Access panels and doors in ductwork are specified in Division 23 – HVAC Ducts and Casings.

I. When access panels or doors are installed in fire rated construction, they shall be fire rated to match the construction.

1.32 FIRESTOP PENETRATION PROTECTION SEALING SYSTEM

A. Where pipes pass through fire partitions, firewalls, floors or ceilings, install a firestop that provides an effective barrier against the spread of fire, smoke, gases and water. Fire-stop material shall be packed tight, and completely fill clearances between pipe, sleeves and structure. All crack voids or holes (up to 4" diameter) shall be sealed using 3M brand Fire Barrier Caulk CP25 or putty 303 or an approved equal. Larger diameter or square holes, 3M system 7902, 7904, 7902R or 7904R or approved equal shall be in accordance with manufacturer's instructions.

B. Fire-stopping material shall maintain its integrity while preventing the passage of flame, smoke, gases or water. Fire-stopping material shall be a one-part, intumescent elastomer noncombustible, noncorrosive and compatible with synthetic cable jackets as defined by ASTM E814 (UL 1479); and in addition for insulation materials, melting points shall be a minimum of 1700 degrees F for one-hour protection and 1850 degrees F for 2-hour protection.

1.33 RECORD DRAWINGS

A. The Contractor shall furnish record as-built drawings to the Architect at completion and acceptance of the job. Transparencies of the original drawings with corrections shall be submitted as specified in the General Requirements.

B. Record all changes from installation originally indicated. Record final location of underground lines by depth from finished grade and by offset distances in feel and tenths to surface improvement such as buildings, curb, or edges of walks. Where work appears on two or more drawings, Contractor shall mark changes on all drawings. Contractor shall mark changes on all drawings. At completion, furnish the above required transparencies to the A/E for approval and record. Drawings shall be certified to be record of work installed and signed by the Contractor. Work shall not be accepted until such drawings have been delivered to the A/E.

1.34 GUARANTEE

A. In addition to the requirements stated in the specifications, the Contractor must guarantee all equipment, materials, and appurtenances installed by him to be free from all defects for a period of one year from date of final acceptance.

B. Upon written notice from the A/E, the Contractor shall promptly correct all defects without additional cost to the Owner. This Contractor shall adjust each part of the entire installation for proper working order. Reports are to be submitted to the A/E and adjustments repeated until the entire system is satisfactory. This Contractor must make good, at his own expense, any defects in materials or workmanship that may appear.

1.35 CLEAN UP

A. The Contractor shall be held responsible for the general clean up of all areas affected by the work in the Contract. All rubbish and accumulative material shall be removed from the premises and the premises left "broom clean" upon completion.

B. All stickers, rust, stains, labels and temporary covers shall be removed before final acceptance.

C. Foreign matter shall be blown, vacuumed or flushed out of piping, pumps, fans, motors, devices, switches, panels, duct work and equipment.

D. Identification plates on equipment shall be free of excess paint and shall be polished.

1.36 OPERATION AND MAINTENANCE MANUALS

A. Submit to the Engineer for approval three manuals covering details of operation maintenance for all apparatus requiring service. The Contractor shall arrange formal instruction sessions by competent representatives of the manufacturer for the Owner's operating personnel to cover the following:

1. Service telephone number, fax number, websites, email addresses, business and service addresses and mobile telephone numbers of the installing contractor, and manufacturer and supplier and parts counters of all equipment.
2. Manufacturer's operating and maintenance manuals, including detailed parts lists with numbers, power and control wiring diagrams for each piece of equipment and accessory requiring services or maintenance, the guarantee period and the name, address and phone number of the nearest sales and service organization for each item. Both on print and CD’s (min 3 copies) form (PDF/MS Word).
3. Cross out options that are not used on equipment sheets, highlight options selected.
4. Step-by-step procedure for starting, stopping, setpoint adjustment, monitoring and alarm enunciation for each system.
5. Copies of inspection certificates provided by the City, County, State and insurance companies.
6. Provide separate Operation and Maintenance Manuals covering the FMCS and in compliance with this section.
7. Routine maintenance procedures and scheduling for all mechanical equipment.

B. Obtain written statements from the Owner's representative acknowledging satisfactory completion of each item of the manuals.

1.37 INSTRUCTION TO OPERATIONAL PERSONNEL

A. Furnish the services of competent instructors to give full instruction to the designated Facilities personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system on the Contract Documents. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

B. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Owner for regular operation. Provide 4 man-hours of instruction for each: chemical treatment/glycol systems, pumps, exhaust and intake fans, heat exchangers, VAV boxes, 8 man-hours for the air handling units and components including the UV system, and 24 man hours instruction for the FMCS (operational, maintenance, programming instruction for trend logging and charting, setpoint adjustment schemes, alarm functionality and other routine operational commands/functions) required by the Owner’s personnel..

C. Instruction shall cover routine maintenance, control and power wiring diagrams and component analysis, preventative maintenance and scheduling, starting and stopping, alarm resets, trend-logging, setpoint adjustment, emergency and normal shutdown/startup, alarm date stamping and all else required by the Owner for complete usage/maintenance/adjustment of equipment in their intended systems.

D. Obtain written statements from the Owner's representative acknowledging satisfactory completion of each item of instructions.

PART 2 - PRODUCTS

2.1 MECHANICAL SLEEVE SEALS

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

1. Acceptable Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Accepted substitute in accordance with Section 01600.

2. Sealing Elements: EPDM interlocking inks, shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel. Include two for each sealing element.

4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.2 SLEEVES

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

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated “wall pipe” equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

2.3 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

E. One-Piece, Stamped-Steel Type: With and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With hinge and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.4 GROUT

A. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, non-staining, noncorrosive, non-gaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000 psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SITE INSPECTION

A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.

B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.

C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.2 PROJECT MANAGEMENT AND COORDINATION

A. Coordination: Coordinate construction operations included in different Sections of the Specification to ensure efficient and orderly installation of each part of the work. Coordinate construction operations, included in different Sections that depend on each other for proper installation, connection, and operation.

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components with other contractors to ensure maximum accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.
4. Where availability of space is limited, coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair of all components, including mechanical and electrical.

B. Prepare memoranda for distribution to each party involved, outlining special procedures required for coordination. Include such items as required notices, reports, and list of attendees at meetings.

1. Prepare similar memoranda for Owner and separate contractors if coordination of their work is required.

C. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities and activities of other contractors to avoid conflicts and to ensure orderly progress of the work. Such administrative activities include, but are not limited to, the following:

1. Preparation of Contractor's Construction Schedule
2. Preparation of the Schedule of Values
3. Installation and removal of temporary facilities and controls
4. Delivery and processing of submittals
5. Progress meetings
6. Pre-installation conferences
7. Project closeout activities
8. Startup and adjustment of systems
9. Project closeout activities

D. Conservation: Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials.

1. Salvage materials and equipment involved in performance of, but not actually incorporated into the work. Refer to other Sections for disposition of salvaged materials that are designated as Owner's property.

3.3 SUBMITTALS

A. Coordination Drawings: Prepare Coordination Drawings if limited space availability necessitates maximum utilization of space for efficient installation of different components or if coordination is required for installation of products and materials fabricated by separate entities.

1. Content: Project-specific information, drawn accurately to scale. Do not base Coordination Drawings on reproductions of the Contract Documents or standard printed data. Include the following information, as applicable:

   a. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems.
   b. Indicate required installation sequenced.
   c. Indicate dimensions shown on the Contract Drawings and make specific note of dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Architect for resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.

2. Number of Copies: Submit three opaque copies of each submittal. Architect, through Construction Manager, will return one copy.

   a. Submit five copies where Coordination Drawings are required for operation and maintenance manuals. Architect and Construction Manager will retain two copies; remainder will be returned. Markup and retain one returned copy as a Project Record Drawing.

3. Refer to individual Sections for Coordination Drawing requirements for work in those Sections.

B. Key Personnel Names: Within 15 days of starting construction operations, submit a list of key personnel assignments, including superintendent and other personnel in attendance at Project Site. Identify individuals and their duties and responsibilities; list addresses and telephone numbers, including home and office telephone numbers. Provide names, addresses, and telephone numbers of individuals assigned as standbys in the absence of individuals assigned to Project.

1. Post copies of list in Project meeting room, in temporary field office, and by each temporary telephone. Keep list current at all times.

3.4 ADMINISTRATIVE AND SUPERVISORY PERSONNEL

A. General: In addition to Project Superintendent, provide other administrative and supervisory personnel as required for proper performance of the work.

3.5 PROJECT MEETINGS

A. General: Schedule and attend meetings and conferences at Project Site, unless otherwise indicated.

1. Agenda: Be prepared for the meeting agenda. Distribute the agenda to all invited attendees.
2. Minutes: Record significant discussions and agreements achieved. Distribute the meeting minutes to everyone concerned, including Owner and Architect, within three days of the meeting.

B. Preconstruction Conference: Attend a preconstruction conference before starting construction, at a time convenient to Owner, Construction Manager, and Architect, but no later than 15 days after execution of the Agreement. Hold the conference at Project site or another convenient location. Conduct the meeting to review responsibilities and personnel assignments.

1. Agenda: Discuss items of significance that could affect progress, including the following:

a. Tentative construction schedule
b. Phasing
c. Critical work sequencing and long-lead items
d. Procedures for processing field decisions and Change Orders
e. Procedures for requests for interpretations (RFIs)
f. Procedures for testing and inspecting
g. Procedures for processing Applications for Payment
h. Submittal procedures
i. LEED requirements
j. Preparation of Record Documents
k. Use of the premises and existing building
l. Work restrictions
m. Owner's occupancy requirements
n. Responsibility for temporary facilities and controls

o. Construction waste management and recycling
p. Parking availability
q. Office, work, and storage areas
r. Equipment deliveries and priorities
s. First aid
t. Security
u. Progress cleaning
v. Working hours

2. Minutes: Record and distribute meeting minutes.

C. Pre-installation Conferences: Attend a pre-installation conference at Project Site before each construction activity that requires coordination with other construction.

1. Attendees: Installer and representatives of manufacturers and fabricators involved in or affected by the installation and its coordination or integration with other materials and installations that have preceded or will follow, shall attend the meeting. Advise Architect and Construction Manager of scheduled meeting dates.
2. Agenda: Review progress of other construction activities and preparations for the particular activity under consideration, including requirements for the following:

a. The Contract Documents
b. Deliveries
c. Review of mockups
d. Possible conflicts
e. Time schedules
f. Manufacturer's written recommendations
g. Acceptability of substrates
h. Temporary facilities and controls

i. Coordination with other work
j. Protection of construction and personnel

3. Record significant conference discussions, agreements, and disagreements, including required corrective measures and actions.
4. Reporting: Distribute minutes of the meeting to each party present and to parties who should have been present.
5. Do not proceed with installation if the conference cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the work and reconvene the conference at earliest feasible date.

D. Progress Meetings: Attend progress meetings at biweekly intervals. Coordinate dates of meetings with preparation of payment requests.

1. Attendees: In addition to representatives of Owner, Construction Manager, and Architect, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the work.

2. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.

    a. Contractor's Construction Schedule: Review progress since the last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor's Construction Schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.

        1) Review schedule for next period.

    b. Review present and future needs of each entity present, including the following:

        1) Interface requirements
        2) Status of submittals
        3) Off-site fabrication
        4) Site utilization
        5) Hazards and risks
        6) Progress cleaning
        7) Status of correction of deficient items
        8) Requests for interpretations (RFIs)
        9) Status of proposal requests
        10) Pending changes
        11) Status of Change Orders
        12) Pending claims and disputes
        13) Documentation of information for payment requests

3. Minutes: Record the meeting minutes.
4. Reporting: Distribute minutes of the meeting to each party present and to parties who should have been present.

    a. Schedule Updating: Revise Contractor's Construction Schedule after each progress meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with the report of each meeting.

3.6 EQUIPMENT LOCATIONS

A. Equipment locations: All mechanical equipment shall be located to provide for manufacturer's recommended clearances, clearance for routine maintenance, clearance per code requirements and locations/clearances required for removal/replacement in the future.

1. Manufacturer's recommended clearances shall include space for proper airflow and non-short circuiting airflow pathway (condensing units, air cooled chillers, cooling towers, etc), clearance for pumps (18" minimum around pumps), 30" clearance or complete access door swings (air handling units), clearances for tube pulls (heat exchangers, chillers, coil pulls, etc); locate piping to be clear of these locations.

2. Provide minimum 36" clearance around boilers, chillers, heat exchangers and other pressure vessels; note this is a minimum requirement, provide excess wherever possible. Provide minimum 42" clearance from power panels per the latest edition NEC having jurisdiction; include requirements for piping and ductwork at such locations.
3. Locate equipment in mechanical rooms to allow for future removal and replacement. Include heights to overhead piping where applicable. Wherever possible, clearances shall include removal/replacement as a whole entity without knock-down.
4. Access platforms with metal grating shall be provided for equipment located outdoors such for power and control panels for air cooled chillers, air handling equipment located on dunnage. This access system shall provide for maintenance and requirements per codes having jurisdiction. Platforms shall include stairs and handrails per OSHA regulations.
5. Locate roof mounted equipment minimum 10’ away from edges of roof. Where equipment is located closer, provide handrail system at roof edge as required per codes having jurisdiction. Maintain clearances from handrail system to power panels.
6. Locate air intakes minimum 10’ away from exhaust outlets and plumbing vents for all other applications.
7. Locate air intakes for kitchen air intakes min 10’ away from exhaust outlets from kitchen exhaust fans.

3.7 ACCEPTANCE TESTING

A. An acceptance test of the HVAC system shall be performed by the Contractor in the presence of the Owner's representative and the Local Fire Marshal. Upon completion of the successful test, the Contractor shall so certify in writing to the Owner and General Contractor.

B. The Contractor shall also utilize all sub-contractors such as sheetmetal, balancing, piping, controls and commissioning agent, and other contractors such as electrical, plumbing, fire alarm and communications as required to perform this acceptance test.

C. The acceptance test shall be performed to determine that the protective measures required as outlined in NFPA 90A and shall function when needed in order to restrict the spread of fire and smoke.

D. The acceptance test shall include testing the HVAC system to determine its full functionability and in compliance with NFPA 90A and the sequence of operation. All controls and equipment shall be modulated throughout their entire ranges and adjustments shall be made for optimum performance.

1. Portions of control or alarm systems are permitted to have standby power or other emergency modes of operation.
2. The tests shall be performed to determine that the system operates under the standby power or emergency operation mode as well as under normal conditions.

E. All fire, smoke, combination fire/smoke dampers and ceiling dampers shall be operated and tested by the Contractor prior to occupancy of a building to determine that they function in accordance with NFPA 90A. A compliance report shall be forwarded to Engineer and Owner.

3.8 CONNECTION TO EXISTING UTILITIES

A. If connecting to an existing piping system (water, gas, oil, sewer, steam, condensate, etc.). It shall be the responsibility of this contractor to verify the integrity of the existing piping system being connected. All applicable testing and acceptance will apply.

B. If connecting to an existing duct system (supply, return, exhaust, etc.). It shall be the responsibility of this contractor to verify the integrity of the existing ducted system being connected. All applicable testing and acceptance will apply.

C. Existing Pipe Testing: The contractor shall remove a section of piping at the point of connection between new and existing. The contractor shall determine the integrity of the existing piping after analysis of the piping section for tube wall thickness, scaling and corrosion. The analysis shall determine the ability for tie-in, pressure testing ability and remaining useful life. The contractor shall guarantee the piping integrity at the point of tie-in and subsequent acceptance. For existing piping not currently being used; the contractor shall pressure test in order to determine integrity and subsequent acceptance. Report all results in writing to the Architect/Engineer.

D. Existing Ductwork Testing: The contractor shall examine the existing ductwork at the point of tie-in pertaining to gauge, reinforcement and joint methods in order to determine the successful tie in and operation of new systems. The contractor shall determine that the existing systems have adequate construction for new system pressure characteristics. The contractor shall guarantee the ductwork integrity at the point of tie in and subsequent acceptance. Report all results in writing to the Architect/Engineer.

3.9 PIPING SYSTEMS – COMMON REQUIREMENTS

A. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern type.
b. Chrome Plated Piping: One piece, cast brass type with polished chrome plated finish.
c. Insulated Piping: One piece, stamped steel type with spring clips.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass type with polished chrome plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, stamped steel type.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: Cast brass type with polished chrome plated finish.
g. Bare Piping at Ceiling Penetrations in Finished Spaces: Set screw.
h. Bare Piping in Unfinished Service Spaces: One piece, cast brass type with finish.
i. Bare Piping in Unfinished Service Spaces: One piece, stamped steel type with hinge.
j. Bare Piping in Equipment Rooms: One piece, cast brass type.
k. Bare Piping in Equipment Rooms: One-piece, stamped steel type.

l. Bare Piping at Floor Penetrations in Equipment Rooms: One piece, floor plate type.

2. Existing Piping: Use the following:

a. Chrome Plated Piping: Split casting, cast brass type with chrome plated finish.
b. Insulated Piping: Split plate, stamped steel type with hinge and spring clips.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast brass type with chrome plated finish.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split plate, stamped steel type with concealed hinge and spring clips.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass type with chrome plated finish.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split plate, stamped steel type with concealed hinge and set screw.
g. Bare Piping in Unfinished Service Spaces: Split casting, cast brass type with finish.
h. Bare Piping in Unfinished Service Spaces: Split plate, stamped steel type with hinge and set screw or spring clips.
i. Bare Piping in Equipment Rooms: Split casting, cast brass type.
j. Bare Piping in Equipment Rooms: Split plate, stamped steel type with set screw or spring clips.
k. Bare Piping at Floor Penetrations in Equipment Rooms: Split casting, floor plate type.

B. Sleeves are not required for core drilled holes, ***except in mechanical and electrical rooms or other wet areas where sleeves shall extend 2 inches above finished floor and shall be made watertight.***

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical and electrical equipment areas or other wet areas 2 inches above finished floor level. Extended cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide ¼ inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
4. Steel Pipe Sleeves: For pipes smaller than 6 inches.

a. Steel Pipe Sleeves: For pipes 6 inches and larger, penetrating gypsum-board partitions.

b. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast iron soil pipe to extend sleeve to 2 inches below finished floor level. Refer to Section 07620 – Sheet Metal Flashing and Trim for flashing.

5. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Section 07920 – Joint Seals for materials and installation.

E. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeves size to allow for 1 inch annular clear space between pipe and sleeves 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.

F. Underground, Exterior Wall Pipe Penetrations: Install cast iron “wall pipes” for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. 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.

G. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 07840 – Firestopping Systems for materials.

H. Verify final equipment locations for roughing-in.

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

END OF SECTION 23 05 00

SECTION 23 05 10 - HVAC DEMOLITION

PART 1 - GENERAL

1.1 STIPULATIONS

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

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 23 Specification Sections, apply to this Section.

1.3 SUMMARY

A. This Section includes the following:

1. Demolition and removal of selected portions of Division 23 systems.
2. Salvage of existing items to be reused or recycled.

B. Related Sections include the following:

1. Division 23 Sections for demolishing, cutting, patching, or relocating mechanical items.

1.4 DEFINITIONS

A. Remove: Detach items from existing construction and legally dispose of them off-site, unless indicated to be removed and salvaged or removed and reinstalled.

B. Remove and Salvage: Detach items from existing construction and deliver them to Owner ready for reuse.

C. Remove and Reinstall: Detach items from existing construction, prepare them for reuse, and reinstall them where indicated.

D. 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.

1.5 MATERIALS OWNERSHIP

A. Except for items or materials indicated to be reused, salvaged, reinstalled, or otherwise indicated to remain Owner's property, demolished materials shall become Contractor's property and shall be removed from Project site.

1.6 SUBMITTALS

A. Proposed Dust-Control and Noise-Control Measures: Submit statement or drawing that indicates the measures proposed for use, proposed locations, and proposed time frame for their operation. Identify options if proposed measures are later determined to be inadequate.

B. Schedule of Selective Demolition Activities: Indicate the following:

1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure Owner's building managers and other tenants' on-site operations are uninterrupted.
2. Interruption of utility services. Indicate how long utility services will be interrupted.
3. Coordination for shutoff, capping, and continuation of utility services.
4. Use of elevator and stairs.
5. Locations of proposed dust- and noise-control temporary partitions and means of egress, including for other tenants affected by selective demolition operations.
6. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.

C. Inventory: After selective demolition is complete, submit a list of items that have been removed and salvaged.

D. Predemolition Photographs or Videotapes: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by selective demolition operations. Comply with Division 01 Section "Photographic Documentation." Submit before Work begins.

E. Landfill Records: Indicate receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.

1.7 QUALITY ASSURANCE

A. Demolition Firm Qualifications: An experienced firm that has specialized in demolition work similar in material and extent to that indicated for this Project.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Standards: Comply with ANSI A10.6 and NFPA 241.

D. Predemolition Conference: Conduct conference at Project site to comply with requirements herein. Review methods and procedures related to selective demolition including, but not limited to, the following:

1. Inspect and discuss condition of construction to be selectively demolished.
2. Review structural load limitations of existing structure.
3. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
5. Requirements of system downtime and scheduling with site personnel.

1.8 PROJECT CONDITIONS

A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted. Provide not less than 72 hours' notice to Owner of activities that will affect Owner's operations.

B. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities.

1. Do not close or obstruct walkways, corridors, or other occupied or used facilities without written permission from authorities having jurisdiction.

C. Owner assumes no responsibility for condition of areas to be selectively demolished.

1. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.
2. Before selective demolition, Owner will remove the following items:

D. Hazardous Materials: Hazardous materials will be encountered in the Work.

1. Hazardous materials will be removed by Owner as part of separate contract.
2. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify Architect, Construction Manager and Owner. Owner will remove hazardous materials under a separate contract.

E. Hazardous Materials: Hazardous materials are present in building to be selectively demolished. A report on the presence of hazardous materials is on file for review and use. Examine report to become aware of locations where hazardous materials are present.

1. Hazardous material remediation is specified elsewhere in the Contract Documents.
2. Do not disturb hazardous materials or items suspected of containing hazardous materials except under procedures specified elsewhere in the Contract Documents.
3. Reference Abatement Contract Documents for locations and removal of all hazardous materials.

F. Storage or sale of removed items or materials on-site is not permitted.

G. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.

1. Maintain fire-protection facilities in service during selective demolition operations.

1.9 WARRANTY

A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties.

1. If possible, retain original Installer or fabricator to patch the exposed Work listed below that is damaged during selective demolition. If it is impossible to engage original Installer or fabricator, engage another recognized experienced and specialized firm.

a. Processed concrete finishes.
b. Stonework and stone masonry.
c. Ornamental metal.
d. Matched-veneer woodwork.
e. Preformed metal panels.
f. Roofing.
g. Firestopping.
h. Window wall system.
i. Stucco and ornamental plaster.
j. Terrazzo.
k. Finished wood flooring.
l. Fluid-applied flooring
m. Aggregate wall coating.
n. Wall covering.
o. Swimming pool finishes.
p. HVAC enclosures, cabinets, or covers.

PART 2 - PRODUCTS

2.1 REPAIR MATERIALS

A. Use repair materials identical to existing materials.

1. If identical materials are unavailable or cannot be used for exposed surfaces, use materials that visually match existing adjacent surfaces to the fullest extent possible.
2. Use materials whose installed performance equals or surpasses that of existing materials.

B. Comply with material and installations requirements specified in individual Specification Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that utilities have been disconnected and capped.

B. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required.

C. Inventory and record the condition of items to be removed and reinstalled and items to be removed and salvaged.

D. When unanticipated mechanical, electrical, or structural elements that conflict with intended function or design are encountered, investigate and measure the nature and extent of conflict. Promptly submit a written report to Architect/Engineer.

E. Engage a professional engineer to survey condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during selective demolition operations.

F. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.

3.2 UTILITY SERVICES

A. Existing Utilities: Maintain services indicated to remain and protect them against damage during selective demolition operations.

B. Do not interrupt existing utilities serving occupied or operating facilities unless authorized in writing by Owner and authorities having jurisdiction. Provide temporary services during interruptions to existing utilities, as acceptable to Owner and to authorities having jurisdiction.

1. Provide at least 72 hours' notice to Owner if shutdown of service is required during changeover.
2. Perform work during unoccupied night or weekend hours as required by Owner during disruption of utilities.

C. Utility Requirements: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.

1. Building Owner or Representative will arrange to shut off indicated services/systems when requested by Contractor.
2. Arrange to shut off indicated utilities with utility companies.
3. If services/systems are required to be removed, relocated, or abandoned, before proceeding with selective demolition provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.

4. Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit after bypassing.

D. Utility Requirements: Refer to Division 23 and 26 Sections for shutting off, disconnecting, removing, and sealing or capping utilities. Do not start selective demolition work until utility disconnecting and sealing have been completed and verified in writing.

3.3 PREPARATION

A. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

1. Comply with requirements for access and protection specified in Division 01 Section "Temporary Facilities and Controls."

B. Temporary Facilities: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.

1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
4. Cover and protect furniture, furnishings, and equipment that have not been removed.
5. Comply with requirements for temporary enclosures, dust control, heating, and cooling specified in Division 01 Section "Temporary Facilities and Controls."

C. Temporary Shoring: Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.

1. Strengthen or add new supports when required during progress of selective demolition.

3.4 SELECTIVE DEMOLITION, GENERAL

A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:

1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.
2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction.

Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.

3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain fire watch and portable fire-suppression devices during flame-cutting operations.
5. Maintain adequate ventilation when using cutting torches.
6. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
7. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
8. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
9. Dispose of demolished items and materials promptly. Comply with requirements in Division 01 Section "Construction Waste Management."
10. Return elements of construction and surfaces that are to remain to condition existing before selective demolition operations begun.
11. Provide demolition on an on-going basis, schedule permitting. Demolition of existing systems or portions there to shall be performed without interruption of the operation of the central heating plant.
12. Remove demolition debris on a continuous and daily basis as work proceeds. Do not leave debris in the room.
13. Schedule and locate dumpster space as required by the project and coordinate location with facility personnel.
14. Remove from site boilers and other large pieces of equipment immediately upon movement. Coordinate schedule of removal trains and cranes with facility personnel so that removal minimizes impact on-site traffic movement.

B. Reuse of Building Elements: Project has been designed to result in end-of-Project rates for reuse of building elements as follows. Do not demolish building elements beyond what is indicated on Drawings without Architect's approval.

1. Non-shell Elements: 50 percent.

C. Removed and Salvaged Items:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers.
3. Store items in a secure area until delivery to Owner.
4. Transport items to Owner's storage area designated by Owner.
5. Protect items from damage during transport and storage.

D. Removed and Reinstalled Items:

1. Clean and repair items to functional condition adequate for intended reuse. Paint equipment to match new equipment.

2. Pack or crate items after cleaning and repairing. Identify contents of containers.
3. Protect items from damage during transport and storage.
4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

E. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.

F. Concrete: Demolish in small sections. Cut concrete to a depth of at least 3/4 inch at junctures with construction to remain, using power-driven saw. Dislodge concrete from reinforcement at perimeter of areas being demolished, cut reinforcement, and then remove remainder of concrete indicated for selective demolition. Neatly trim openings to dimensions indicated.

G. Concrete: Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals, using power-driven saw, then remove concrete between saw cuts.

H. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain and at regular intervals, using power-driven saw, then remove concrete between saw cuts.

I. Concrete Slabs-on-Grade: Saw cut perimeter of area to be demolished, then break up and remove.

J. Resilient Floor Coverings: Remove floor coverings and adhesive according to recommendations in RFCI-WP and its Addendum.

1. Remove residual adhesive and prepare substrate for new floor coverings by one of the methods recommended by RFCI.

K. Roofing: Remove no more existing roofing than can be covered in one day by new roofing. Refer to applicable Division 07 Section for new roofing requirements.

L. Air-Conditioning Equipment: Remove equipment without releasing refrigerants.

3.5 DISPOSAL OF DEMOLISHED MATERIALS

A. General: Except for items or materials indicated to be recycled, reused, salvaged, reinstalled, or otherwise indicated to remain Owner's property, remove demolished materials from Project site and legally dispose of them in an EPA-approved landfill.

1. Do not allow demolished materials to accumulate on-site.
2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
3. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.

4. Comply with requirements specified in Division 01 Section "Construction Waste Management."

B. Burning: Do not burn demolished materials.

C. Disposal: Transport demolished materials off Owner's property and legally dispose of them.

3.6 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

END OF SECTION 23 05 10

SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 STIPULATIONS

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

1.2 RELATED DOCUMENTS

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

1.3 SUMMARY

A. This Section includes basic requirements for factory and field installed motors.

1.4 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.5 SUBMITTALS

A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; enclosure type and mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.

B. Shop Drawings for Field-Installed Motors: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

1. Each installed unit's type and details.
2. Nameplate legends.
3. Diagrams of power, signal, and control wiring. Provide schematic wiring diagram for each type of motor and for each control scheme.

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around field-installed motors. Show motor layout, mechanical power transfer link, driven load, and relationship between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Manufacturer Seismic Qualification Certification: Submit certification that motors, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls". Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For testing agency.

F. Source quality-control test reports.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For field-installed motors to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

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

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain field-installed motors through one source from a single manufacturer.

C. Product Options for Field-Installed Motors: Drawings indicate size, profiles, and dimensional requirements of motors and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

D. 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.

E. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices and features that comply with the following:

1. Compatible with the following:

    a. Magnetic controllers.
    b. Multispeed controllers.
    c. Reduced-voltage controllers.

2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
3. Matched to torque and horsepower requirements of the load.
4. Matched to ratings and characteristics of supply circuit and required control sequence.

B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

A. Motor requirements apply to factory and field installed motors except as follows:

1. Different ratings, performance, or characteristics for motor are specified in another Section.
2. Motorized-equipment manufacturer requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.2 MOTOR CHARACTERISTICS

A. Motors [**1/2**] HP and Larger: Three phase. Unless otherwise specified.

B. Motors smaller than [**1/2**] HP: Single phase. Unless otherwise specified.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open drip-proof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.

G. 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.

H. Enclosure: Open drip-proof.

2.3 POLYPHASE MOTORS

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

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

C. Stator: Copper windings, unless otherwise indicated.

1. Multispeed motors shall have separate winding for each speed.

D. Rotor: Squirrel cage, unless otherwise indicated.

E. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating, unless otherwise indicated.

G. Insulation: Class F, unless otherwise indicated.

H. 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.

I. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.

1. Finish: Gray enamel or as approved by Engineer.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Inrush 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. Designed with critical vibration frequencies outside operating range of controller output.
2. Temperature Rise: Matched to rating for Class B insulation.
3. Insulation: Class H.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
5. Ground motor shafts.

C. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with non-hygroscopic material.

1. Finish: Chemical-resistant paint over corrosion-resistant primer.

D. Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

2.5 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:

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

B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

C. 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.

D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, pre-lubricated-sleeve type for other single-phase motors.

E. Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before motor installation.

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

3.2 FIELD-INSTALLED MOTOR INSTALLATION

A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.

B. Install motors on concrete bases complying with Division 03.

C. Comply with mounting and anchoring requirements specified in Division 23 Section "Vibration and Seismic Controls."

3.3 FIELD QUALITY CONTROL FOR FIELD-INSTALLED MOTORS

A. Prepare for acceptance tests.

1. Align motors, bases, shafts, pulleys, and belts. Tension belts according to manufacturer's written instructions.
2. Verify bearing lubrication.
3. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
4. Test interlocks and control and safety features for proper operation.
5. Verify that current and voltage for each phase comply with nameplate rating and NEMA MG 1 tolerances.

B. 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.

C. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

E. Perform the following field tests and inspections and prepare test reports:

1. Perform electrical tests and visual and mechanical inspections including optional tests and inspections stated in NETA ATS on factory and field installed motors. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.4 FIELD-INSTALLED MOTOR DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain field-installed motors. Refer to Division 01 Section "Closeout Procedures and Demonstration and Training."

END OF SECTION 23 05 13

SECTION 23 05 29 - HANGERS & SUPPORTS FOR HVAC PIPING & EQUIPMENT

PART 1 - GENERAL

1.1 STIPULATIONS

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

1.2 WORK INCLUDED

A. This Section includes hangers, supports, anchors, sleeves, seals, flashing and sealing for mechanical system piping and equipment.

1.3 RELATED WORK

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

B. Related Sections include:

1. Division 05 Section "Metal Fabrications" for materials for attaching hangers and supports to building structure.
2. Division 21 Sections on fire-suppression piping for fire-suppression pipe hangers.
3. Division 23 Section "Vibration Isolation for HVAC Components" for vibration isolation and seismic restraint devices.

1.4 REFERENCES

A. ASTM A 36/A 36M-00a: Specification for Carbon Structural Steel

B. ASTM A 780-00: Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

C. ASTM C 533-95: Specification for Calcium Silicate Block and Pipe Thermal Insulation

D. ASTM C 552-00 (Revised 2001): Specification for Cellular Glass Thermal Insulation

E. ASTM C 1107-99: Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

F. ASME B31.9-96: Building Services Piping

G. 2001 ASME Boiler and Pressure Vessel Code: Section II, "Materials"; Section IX, "Welding and Brazing Qualifications"

H. AWS D1.1-00: Structural Welding Code – Steel

I. MSS SP-58-93: Pipe Hangers and Supports – Materials, Design and Manufacture

J. MSS SP-69-96: Pipe Hangers and Supports – Selection and Application

K. MSS SP-89-98: Pipe Hangers and Supports – Fabrication and Installation Practices

L. MSS SP-90-00: (Reaffirmed 1991): Guidelines on Terminology for Pipe Hangers and Supports

M. MFMA-3-99: Metal Framing Standards Publication

N. MFMA-102-99: Guidelines for the Use of Metal Framing

O. SSPC-PA 1-2000: Paint Application Specification No. 1: Shop, Field and Maintenance Painting

P. IAPMO PS 42-96: Pipe Alignment and Secondary Support Systems

1.5 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.6 PERFORMANCE REQUIREMENTS

A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

C. Design seismic restraint hangers and supports for piping and equipment.

1.7 SUBMITTALS

A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports and trapeze hangers. Include design calculations and indicate size and characteristics of components and fabrication details.

C. Welding Certificates: Copies of certificates for welding procedures and operators.

1.8 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Pipe Hangers:

a. B-Line Systems, Inc.
b. Carpenter & Patterson, Inc.
c. Grinnell Corp.

2. Channel Support Systems:

a. B-Line Systems, Inc.
b. Grinnell Corp.; Power-Strut Unit.
c. Unistrut Corp.

3. Thermal-Hanger Shield Inserts:

a. Carpenter & Patterson, Inc.
b. Michigan Hanger Co., Inc.
c. Pipe Shields, Inc.

4. Powder-Actuated Fastener Systems:

a. Gunnebo Fastening Corp.
b. Hilti, Inc.
c. ITW Ramset/Red Head.
d. Masterset Fastening Systems, Inc.

5. Piping supports systems for Roofs:

   a. Miro Industries, Inc.
   b. Curbs-Plus, Inc.
   c. PHP Systems/Design
   d. Reviewed Equivalent

2.2 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

   1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
   2. Corrosion resistant for piping located outdoors such as including but not limited to steam piping.
   3. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with non-insulated copper tubing.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

   1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
   2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: 100-psi minimum compressive-strength insulation, encased in sheet metal shield.

   1. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier.
   2. Material for Hot Piping: ASTM C 552, Type I cellular glass for water and calcium silicate for steam and other high temperature pipes.
   3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
   4. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
   5. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

D. Roof Support Systems:

   1. Provide an engineered piping support system by Miro or reviewed equivalent for all piping to be supported directly on the rubber roof. System shall be designed to spread the load of each support over a wide area to minimize point loading and provide a stable base as not to crush the polysio roof insulation. Pipe supports shall be provided with a means to protect the rubber roof from any punctures or abrasions that could result in leaks.
   2. All pipes shall be supported from adjustable height pipe rollers to allow longitudinal pipe movement from thermal expansion. Pipe roller system shall be designed to accommodate insulted piping. thermal expansion. Pipe roller system shall be designed to accommodate insulted piping. Pipe support system to account for roof pitch and piping pitch for secure support of piping systems.

2.3 MISCELLANEOUS MATERIALS

A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

C. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.

D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
2. Properties: Nonstaining, noncorrosive, and nongaseous.
3. Design Mix: 5000-psi, 28-day compressive strength.

2.4 HANGER RODS

A. Steel Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.

2.5 INSERTS

A. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustable, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit hanger rods. Inserts not allowed on piping 2 inches and larger.

2.6 FLASHING

A. Metal Flashing: 26 gauge galvanized steel.

B. Lead Flashing: 5 lb./sq. ft. sheet lead for waterproofing; one lb./sq. ft. sheet lead for soundproofing.

C. Flexible Flashing: Thick sheet butyl; compatible with roofing.

D. Caps: Steel, 22 gauge minimum; 16 gauge at fire resistant elements.

2.7 SLEEVES

A. Sleeves for Pipes: Schedule 10, black steel.

B. Sleeves for Ductwork: 18 gauge, black steel.

C. Fire Stopping Insulation: Glass fiber type, non-combustible.

D. Caulk: Acrylic sealant.

2.8 FABRICATION

A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

B. Design hangers without disengagement of supported pipe.

C. Provide copper plated hangers and supports for copper piping.

2.9 SEALS

A. Mechanical Type; Interlocking synthetic rubber links; pressure plates and compression bolts. Include sleeve from same manufacturer.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

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

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification 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 120 to 450 deg F pipes, NPS 4 to NPS 16, 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 24, 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 2.

10. Split Pipe-Ring with or without Turnbuckle-Adjustment 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 pipe, 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.
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 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 20, 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 not necessary.
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 not necessary.
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.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification 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.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

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

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

G. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification 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 by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

H. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification 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 absorb 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 absorb 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 absorb 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.

3.2 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Field assemble and install according to manufacturer's written instructions.

C. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

D. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, 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.

E. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

F. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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

H. 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.

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

J. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.

K. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

    a. All Insulated Piping: Clamp shall not project through insulation.
    b. All Insulated Piping: Use thermal-hanger shield and insert with clamp sized to match OD of insert. Pipe insulation and jacket shall be continuous, provide pipe accessories as required.
    c. Do not exceed pipe stress limits according to ASME B31.9.

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. 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 arc of 180 degrees.

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

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

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

5. Pipes NPS 8 and Larger: Include wood inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

L. Supports shall secure pipes in place, shall prevent pipe vibration, maintain required grading by proper adjustment, provide for expansion and contraction and shall make a neat appearance. Supports shall be of strength and rigidity to suit loading, service and installed in a manner in which will not stress unduly the building construction. Hangers shall not be permitted from roof and floor slabs. Fasten hangers and supports to building framing wherever practicable. Where required, add supplementary steel members to support piping. Hangers shall be capable of vertical adjustment after piping is erected. Hanger rods shall not pierce ducts.

1. Support horizontal piping of steel as per following schedule:

    a. NPS 3/4: Maximum span, 8 feet; minimum rod size, 1/4 inch
    b. NPS 1: Maximum span, 8 feet; minimum rod size, 1/4 inch
    c. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch
    d. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch
    e. NPS 2-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch
    f. NPS 3: Maximum span, 8 feet; minimum rod size, 3/8 inch
    g. NPS 4: Maximum span, 8 feet; minimum rod size, 1/2 inch
    h. NPS 6: Maximum span, 8 feet; minimum rod size, 1/2 inch
    i. NPS 8: Maximum span, 8 feet; minimum rod size, 5/8 inch
    j. NPS 10: Maximum span, 8 feet; minimum rod size, 3/4 inch
    k. NPS 12: Maximum span, 8 feet; minimum rod size, 7/8 inch
    l. NPS 14: Maximum span, 8 feet; minimum rod size, 1 inch
    m. NPS 16: Maximum span, 8 feet; minimum rod size, 1 inch
    n. NPS 18: Maximum span, 8 feet; minimum rod size, 1-1/4 inches
    o. NPS 20: Maximum span, 8 feet; minimum rod size, 1-1/4 inches

2. Support horizontal copper tubing as per following schedule:

    a. NPS 1/2: Maximum span, 6 feet; minimum rod size, 1/4 inch
    b. NPS 3/4: Maximum span, 6 feet; minimum rod size, 1/4 inch
    c. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch
    d. NPS 1-1/2: Maximum span, 10 feet; minimum rod size, 3/8 inch
    e. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch
    f. NPS 2-1/2: Maximum span, 10 feet; minimum rod size, 3/8 inch
    g. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch

Rod diameter shall be the same as specified for steel pipe. Support plastic piping in accordance with manufacturer's published recommendations.

3. Vertical Piping Supports

   a. Cast Iron and Steel: Support at each floor and intermediates by stays or bracing with a maximum spacing of 10 feet unless otherwise required by expansion conditions.
   b. Copper Tubing: Support at each floor intermediates by stays or bracing with a maximum spacing of 10 feet to prevent rattling and vibration, unless otherwise required by expansion conditions.
   c. Plastic and Glass: Support in accordance with published manufacturer's recommendations.
   d. Support vertical lines which rise from lowest story with base fitting set on concrete or brick pier, or by hangers located on horizontal connections to riser.
   e. Bolt pipe riser clamps securely to pipe; rest clamp and extension on building structure. In special cases where directed, weld clamp to pipe and to building steel. Where required, provide supplementary steel members for clamp rest.

3.3 FLASHING

A. Provide flexible flashing and metal counter flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.

B. Flash vent and soil pipes projecting 3 inches minimum above finished roof surface with lead worked one-inch minimum into hub, 8 inches sheet clear on sides with 24 x 24 inches sheet size. For pipes through outside walls, turn flanges back into wall and caulk metal counter flash and seal.

C. Seal floor, shower and mop sink drains watertight to adjacent materials.

D. Provide curbs for mechanical roof installations 14 inches minimum high above roofing surface. Flexible sheet flash and counter flash with sheet metal; seal watertight.

3.4 SLEEVES

A. Provide sleeves at all pipe penetrations of floor and walls.

B. Extend sleeves through floors one inch above finished floor level. Grout sleeves in place. Staff joint with fire stop insulation and caulk seal airtight.

C. Duct penetrations of non-rated floors and walls shall have the edge joint stuffed with insulation and the caulk sealed, airtight. No sleeve is required.

D. Duct penetrations of rated partitions and floor shall be sleeved with 12 gauge galvanized steel as per UL fire damper detail. Caulk all floor penetrations watertight between the floor and sleeve with fireproof caulk, airtight.

E. Install chrome plated steel escutcheons at finished surface.

F. Use mechanical seals at exterior wall pipe penetrations below grade.

3.5 EQUIPMENT SUPPORTS

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

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

3.6 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes 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 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 contours of welded surfaces match adjacent contours.

3.7 ADJUSTING

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

3.8 PAINTING

A. Touching Up: 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. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

C. Ceiling Plates: Where hanging rods or piping leave unsightly holes in ceilings in finished areas, provide plastic ceiling plates, Grinnell Figure 127 or cast iron ceiling plates with setscrew, Grinnell Figure 395.

END OF SECTION 23 05 29

SECTION 23 05 48 - VIBRATION ISOLATION & SEISMIC RESTRAINTS FOR HVAC COMPONENTS

PART 1 - GENERAL

1.1 STIPULATIONS

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

1.2 DESCRIPTION

A. Intent

1. The work associated of the facility shall include seismic attachment of components as required by the International Building Code of New York State 2006. The seismic classification has been determined to be as follows:

    a. Site Class: D
    b. Facility Zip Code: 13827
    c. Building Seismic Use Group: 111
    d. Short Period Response Accelerations S_s: 0.162
    e. 1 Second Period Response Acceleration S_1: 0.056
    f. Seismic Design Category: C
    g. These values and seismic design category determinations are provided for information purposes only. The actual values should be verified by the Attachment Engineer of Record and Attachment Design Stamped by the Professional Engineer of Record.

2. Based upon the Seismic Design Category C, D or E as stated above, the following items have been identified as requiring seismic, including but not limited to:

    <u>Life Safety and Hazardous Systems</u> [For Seismic Design Category C]

    a. Heating Piping
    b. Air Handling Systems (Heating and Cooling)
    c. Curbs
    d. Equipment Supports
    e. Roof top exhaust fans
    f. Heat Exchangers
    g. Ductwork
    h. Natural Gas Piping
    i. Pumps
    j. Risers
    k. Supports
    l. Tanks

m. Vibration Isolators
n. Rooftop Units (Gas Fired & water source heat pump)

3. This contractor is required to obtain the services of a Seismic Engineer to provide Seismic Certification and Analysis. Items identified in Item B above are at a minimum to be seismically braced but all systems need to be analyzed by the Seismic Engineer of record for compliance with the International Building Code. Exceptions may or may not apply depending upon the importance of the component being braced, the distance from the structure and the interrelationship of components, their supports, and their affect on each other. The interrelationship of the components shall be considered so that the failure of an essential or nonessential architectural, mechanical or electrical component shall not cause the failure of an essential architectural, mechanical or electrical component. In order to comply with this interrelationship of components clause, the Seismic Engineer must consider the coordination of all systems and components being installed. Exceptions to seismic bracing may or may not apply.
4. All equipment, piping, ductwork and conduit as noted on the drawings schedule or in the specification shall be seismically braced. Vibration control shall apply as described herein.
5. Seismic bracing and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.
6. It is the intent of the seismic portion of this specification to keep all mechanical, electrical, plumbing and fire protection building system components in place during a seismic event and operational where this specification so requires.
7. All such systems must be installed in strict accordance with seismic codes, component manufacturer's and building construction standards. Whenever a conflict occurs between the manufacturers or construction standards, the most stringent shall apply.
8. This specification is considered to be minimum requirements for seismic consideration.
9. Any variance or non-compliance with this specification requirements shall be corrected by the contractor in an approved manner.

B. The work in this section includes, but is not limited to the following:

1. Vibration isolation for piping, ductwork, conduit and equipment.
2. Equipment isolation bases.
3. Seismic restraints for isolated equipment.
4. Seismic restraints for non-isolated equipment
5. Certification of seismic restraint designs and installation supervision.
6. Certification of seismic attachment of housekeeping pads.
7. All equipment (components) requiring IBC certification.
8. All inspection and test procedures for equipment (components) requiring IBC certification.
9. All mechanical, electrical, plumbing or fire protection equipment and systems within or on the building. Equipment buried underground is included. Entry of services to building, up to but not including the utility connection point is part of this Specification.

Equipment referred to below is typical. (Equipment not listed is still included in this specification)

For IBC projects, all systems listed in or part of this paragraph are referred to as components:

Air Handling Units	Pumps (all types)
Condensers	Risers
Curbs	Rooftop Units
Ductwork	Supports
Equipment Supports	Unit Ventilators
Fans (all types)	Variable Frequency Drives
Heat Exchangers	Vibration Isolators
Pipe	

C. Definitions *(all codes).*

1. Life Safety Systems:

   a. All systems involved with fire protection including sprinkler piping, jockey pumps, fire pumps, control panels, service water supply piping, water tanks, fire dampers and smoke exhaust systems and fire alarm panels.
   b. All mechanical, electrical, plumbing or fire protection systems that support the operation of or are connected to emergency power equipment including all lighting, generators, transfer switches and transformers.
   c. All medical and life support systems.
   d. Hospital heating systems and air conditioning systems for maintaining normal ambient temperature.
   e. Automated supply, exhaust, fresh air and relief air systems on emergency control sequence including air handlers, duct, dampers, etc. or manually operated systems used for smoke evacuation, purge or fresh air relief by the fire department.

2. Positive Attachment:

   a. Positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double-sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, fire protection or any other equipment are not acceptable on this project as seismic bracing points.

3. Transverse Bracing:

   a. Restraint(s) applied to limit motion perpendicular to the centerline of the pipe or duct.

4. Longitudinal Bracing:

   a. Restraint(s) applied to limit motion parallel to the centerline of the pipe or duct.

5. Definitions, IBC *(in addition to the above)*

   Anchor: A device, such as an expansion bolt, for connecting duct or pipe bracing members into the structure of a building.

Approved Agency: An established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved.

Attachment: See **Positive Attachment** below.

Bracing: Metal channels, cables or hanger angles that prevent ducts and pipes from breaking away from the structure during an earthquake. See also Longitudinal Bracing and **Transverse Bracing**. Together, they resist lateral loads from any direction.

Certificate of Compliance: A certificate stating that materials and products meet specified standards or that work was done in compliance with approved construction documents, provided by an approved agency.

Component: A part or element of an electrical or mechanical system.

Component, equipment: A mechanical or electrical component or element that is part of a mechanical and/or electrical system within or without a building system.

Component, flexible: Component, including its attachments, having a fundamental period greater than 0.06 seconds.

Component, rigid: Component, including its attachments, having a fundamental period less than or equal to 0.06 seconds.

Dynamic properties of piping: The tendency of pipe to change in weight and size because of the movement and temperature of fluids in them. This does not refer to movement due to seismic forces.

Equipment: Systems associated with ducts, pipes and conduit, also called components.

Gas pipes: For the purpose of this Specification Guide, gas pipe is any pipe that carries fuel gas, fuel oil, medical gas, or compressed air.

Hazardous Contents: A material that is highly toxic or potentially explosive and in sufficient quantity to pose a significant life-safety threat to the general public if an uncontrolled release were to occur.

Inspection Certificate: An identification applied on a product by an approved agency containing the name of the manufacturer, the function and performance characteristics, and the name and identification of an approved agency that indicates that the product or material has been inspected and evaluated by an approved agency *(see Section 1703.5 and "Label" and "Manufacturer's Designation" and "Mark")*.

Label: An identification applied on a product by the manufacturer that contains the name of the manufacturer, the function and performance characteristics of the product or material, and the name and identification of an approved agency and that indicates that the representative sample of the product or material has been tested and evaluated by an approved agency *(see Section 1703.5 and "Inspection Certificate" and "Manufacturer's Designation" and "Mark")*.

Lateral forces: A force acting on a duct or pipe in the horizontal plane. This force can be in any direction.

Load: Gravity Load *(W)*: The total dead load and applicable portions of other loads *as defined in Section 1613 through 1622.*

Longitudinal bracing: Bracing that prevents a duct or pipe from moving in the direction of its run.

Longitudinal force: A lateral force that happens to be in the same direction as the duct or pipe.

Manufacturer's Designation: An identification applied on a product by the manufacturer indicating that a product or material complies with a specified standard or set rules *(see also "Inspection Certificate" and "Label").*

Occupancy Importance Factor: A factor assigned to each structure according to its Seismic Use Group as prescribed in the IBC.

Positive Attachment: A mechanical device, designed to resist seismic forces that connects a non-structural element, such as a duct, to a structural element, such as a beam. Bolts and screws are examples of positive attachments. Glue and friction due to gravity do not create positive attachments.

Seismic Design Category: A classification assigned to a structure based on its Seismic Use Group and the severity of the design earthquake ground motion at the site.

Seismic Forces: The assumed forces prescribed herein, related to the response of the structure to earthquake motions, to be used in the design of the structure and its components.

Seismic Use Group: A classification assigned to a building based on its use as defined in *Section 1616.2.*

Seismic: (adj.) Related to an earthquake. Seismic loads on a structure are caused by wave movements in the earth during an earthquake.

Site Class: A classification assigned to a site based on the types of soils present and their engineering properties as defined in *Section 1615.1.5.*

Special Inspection, Continuous: The full-time observation of work requiring special inspection by an approved special inspector who is present in the area where the work is being performed.

Special Inspection, Periodic: The part-time or intermittent observation of work requiring special inspection by an approved special inspector who is present in the area where the work has been or is being performed and at the completion of the work.

Special Inspection: Inspection as herein required of the materials, installation, fabrication, election or placement of components and connections requiring special documents and referenced standards *(see Section 1704).*

Story Drift Ratio: The story drift divided by the story height.

Transverse bracing: Bracing that prevents a duct or pipe from moving from side to side.

1.3 QUALITY ASSURANCE

A. For both Non-IBC and IBC Projects substitution of internally or externally isolated and restrained equipment supplied by the equipment vendor, in lieu of the isolation and restraints specified in this section, is acceptable provided all conditions of this section are met. The Equipment manufacturer shall provide a letter of guarantee from their Engineering Department PE stamped and certified per the section on Seismic Restraint Design (See paragraph 1.3) stating that the seismic restraints are in full compliance with these specifications. Where IBC is required, manufacturer certification shall be in addition to all requirements which are stated in Paragraph 1.3 of Article 4.

Letters from field offices or representatives are unacceptable. All costs for converting to the specified vibration isolation and/or restraints shall be borne by the equipment vendor in the event of non-compliance with the proceeding. Internal isolation is not acceptable for:

- Indoor or outdoor mounted equipment over or adjacent to:
  - Patient or operating areas
  - Theatre space
  - Office locations
  - Assembly areas

B. Letters from representatives are unacceptable.

1.4 SUBMITTAL DATA REQUIREMENTS

A. Refer to Part I General Requirements.

B. The manufacturer of vibration isolation and seismic restraints shall provide submittals for products as follows:

1. Descriptive Data:

a. Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the specification.
b. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive drawings.

2. Shop Drawings:

   a. Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.
   b. Provide all details of suspension and support for ceiling hung equipment.
   c. Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.
   d. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

3. Seismic Certification and Analysis:

   a. Calculations by the Manufacturer's qualified licensed Engineer substantiating the mounting system, seismic restraints and recommended anchor bolts shall be submitted for approval along with the shop drawings. Calculations shall be based on the loads as established in *Section 4d – Design Loads* at the end of this section. All analysis shall be stamped by a registered professional having a PE from the same state as the project.
   b. Unless otherwise specified, all equipment, piping and ductwork shall be restrained to resist seismic forces. Restraints shall maintain mechanical equipment, piping or ductwork in a captive position. Restraint devices shall be designed and selected to meet seismic requirements as defined in the latest issue of:

      - Uniform Building Code
      - New York State Building Code
      - Applicable state and local codes
      - NFPA, (fire protection only).
      - IBC International Building Code (See paragraph 4).

   c. Site Seismic Design Criteria

      1) Seismic Design Category: C

4. International Building Code Additions:

   In addition to all of the above provisions, all trades shall comply with sections 16 & 17 of the International Building Code using only vendors that comply with the provisions stated herein and submitting the special inspections listed within these specifications. Where compliance is not possible, each contractor shall submit a vendor report clearly indicating that none of the specified, listed or other vendors known to the contractors meet the compliance, testing and certification portions of the IBC specifications Section 16 and 17. Special inspections shall still be conducted (Paragraph 4 b) even if no vendors meet the following requirements. All non-isolated and isolated equipment, (components) shall be secured to the structure in accordance with that code.

4a. All component manufacturers will submit for approval the following as required below:

- All **life safety system** components noted in this specification will have the manufacturer of that component submit the Approved Agencies Certificate of Compliance for the specific equipment on this project when the Seismic Design Category if "C-F". Analytical or Shaker Test certification thru the component's load path including structure at its center of gravity shall include **anchorage, structural** and **online capability**.

- For **Seismic Hazard Exposure Group IV** projects, all components noted in this specification will have the manufacturer of that component submit the Approved Agencies Certificate of Compliance for their equipment when the Seismic Design Category is "C-F". This requirement also pertains to projects that combine an emergency preparedness center within a structure of another Use Group where that component is needed for continued operation of the building or whose failure could impair the continued operation of the building. Note: the definition of the above refers to any component which does not allow or hampers the use or capability of the intended purpose of that structure Analytical or Shaker Test certification through the total component's load path to structure at its center of gravity shall include **anchorage**, **structural** and **on line capability**.

- All components containing **Hazardous** or **Flammable** materials will have the manufacturer of that component submit the Approved Agencies Certificate of Compliance for their equipment when used on any project having a minimum Seismic Design Category of "C-F". Analytical or Shaker Test certification through the total component's load path to structure at its center of gravity shall include **anchorage, structural on line capability** to insure against loss of hazardous or flammable (explosive) material. Test shall prove that no internal component will fail which could support combustion and/or explosion.

- All **COMPONENTS NOT LISTED IN THE ABOVE CATEGORIES** shall have the manufacturer of each component submit a PE stamped calculation package that their project specific equipment will accept anchorage through the component's load path to structure at its center of gravity at the designated anchorage locations. This requirement is for all projects having a Seismic Design Category of C-F.

4b. The following systems shall require Special Inspection and Periodic Special Inspection for anchorage during the course of construction, as defined earlier in this section for all buildings in Seismic Design Categories C-F.

- All smoke control systems Periodic Special Inspection during erection of ductwork and prior to concealment, for leakage testing. Additionally, prior to occupancy for pressure differential testing (see IBC-2000, section 1704.14).
- All electrical components for standby or emergency power systems require Periodic Special inspection.*
- All electrical equipment in Seismic Design Categories E and F. (Periodic)*
- All flammable, combustible and highly toxic piping and their associated mechanical systems. (Periodic)*

- All ductwork containing hazardous materials. (Periodic)*
- All equipment using combustible or toxic energy sources. (Special $^{-1}$)
- All electric motors, transformers, switchgear unit substations and motor control centers. (Special $^{-1}$)
- Reciprocating and rotating type machine. (Special $^{-1}$)
- Pipe, 3" and larger. (Special $^{-1}$)
- Tanks, heat exchangers and pressure vessels. (Special $^{-1}$)
- Isolator units for seismic isolation system (Periodic) *
- Manufacturer's Quality Control Program for projects in Seismic Design Categories E or F.

4c. Contractor Responsibilities and Approvals:

Each contractor responsible for the installation of the components asterisked above, (*) shall be responsible for submitting to the design team for their approval, a written contractor's statement of responsibility as outlined below. In addition all (-1) items above require special inspection in accordance with *IBC Section 1707.7.1.*

- Identify the components that are part of the Quality Assurance Plan. (asterisked above)*
- Identify all Special Inspection and Testing for components installed as part of this contract.
- Listed control procedures within the contractor's organization for all special inspection and testing including methods, frequency of reporting and their distribution of those reports.
- List personnel and their qualifications exercising control over the seismic aspects of the project.

4d. Design loads:

a. Projects located in the states of Connecticut, Delaware, New Jersey, New York and Pennsylvania, have a maximum design load of .4g for statically mounted components and .9g for resiliently mounted components. Actual loads shall be as above or as calculated but shall not be less than .4g for static and .5g for resiliently mounted components including internal components as part of a manufactured system.

b. Exclusions for seismic restraint of piping and duct shall be according go applicable codes. The minimum horizontal restraint capability shall be .4g horizontal and .27g vertical. Life safety equipment defined above shall be designed to survive a horizontal load of .9g and a vertical load of .6g.

c. Testing or calculations (including the combining of tensile and shear loadings) to support seismic restraint designs must be stamped by a registered PE with at least five years of seismic design experience and licensed in the state of the job location. Testing and calculations must include shear and tensile loads as well as one test or analysis at 45º to the weakest mode. IBC Component testing must be by an Approved Agency.

d. Analysis for anchorage must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces detailed in Section 4 acting through the equipment center of gravity. Overturning moments may exceed forces at ground level.

e. Vertical load shall be calculated at 2/3 the horizontal load.

f. Internally isolated equipment in lieu of specified isolation and restraint systems must meet all of the requirements of paragraph 4 (a-d) and Section 1.6.

g. A seismic design Errors and Omissions insurance certificate **MUST** accompany the equipment manufacturer's certification. Product liability insurance certificates are not acceptable.

h. In the event that the equipment is internally isolated and restrained, the entire unit assembly must be seismically attached to the structure. Curb or roof rail mounted equipment must not only have seismic attachment of the equipment to the roof but also to the curb or rails. The attachment and certification thereof shall be by this section. Sheet metal screw attachment is unacceptable.

i. Failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8 inch and/or horizontal permanent deformation greater than 1/4 inch or failure of the equipment to operate.

1.5 RELATED WORK

A. Housekeeping pad design shall be by the project structural engineer or as shown on the contract drawings. Attachment shall be designed and certified according to this section by the seismic/isolation supplier. Material and labor required for attachment and construction shall be by the concrete section contractor, or by this contractor where specified. Housekeeping pads shall be sized to accommodate a minimum of 6" of clearance all around the equipment or 12 times the anchor bolt diameter, whichever is greater. Where exterior isolators are used this distance shall be as measured from the outboard holes in the isolator base plate and its mounting package.

B. Structural support and connections for all equipment, including roof-mounted equipment, specified in other sections shall comply with all IBC requirements indicating load path to the structure.

C. Roof steel supporting roof-mounted equipment shall be designed for all seismic forces including, but not limited to, tension, compression and moment loads.

D. Chimneys, stacks and boiler breeching passing through floors are to be bolted at each floor level or secured above and below each floor with riser clamps.

E. Where ceilings are not braced (Exclusion "C" – Building Category I and II I_p = 1.0 *Section 1621.2.5*) lighting fixtures shall have independent 4 corner diagonal wire ties to structure.

F. Lay-in ceilings in compliance with seismic zone requirements may use earthquake clips or otherwise approved means of positive attachment to brace fixtures such as panel light and diffusers less than 75 pounds to T-bar structures. Local codes dictate support requirements.

1.6 CODE AND STANDARDS REQUIREMENTS

A. Typical Applicable Codes and Standards

1. All City, State and Local Codes (Code)
2. New York State Building Code 2015
3. SMACNA Guidelines for Seismic Restraint of Mechanical Systems (to be used as a Standard, not a code)
4. NFPA 13 and 14 for Fire Protection System (Standard)
5. American Society For Testing and Materials (ASTM) (Standard)
6. International Conference of Building Officials (ICBO) (Standard)
7. Internal Building Code (Code)
8. Uniform Building Code (Code)
9. ASHRAE (Standard)

B. In cases where requirements vary, the guideline for the most stringent shall be utilized.

C. Use IBC-2015 as reference code standard unless otherwise designated.

1.7 MANUFACTURER'S RESPONSIBILITY

A. Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:

1. Determine vibration isolation and seismic restraint sizes and locations.
2. Provide vibration isolation and seismic restraints as scheduled or specified.
3. Provide calculations and materials if required for restraint of unisolated equipment.
4. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.
5. Certify correctness of installation upon completion.
6. All provisions of Section 1.3, Section "C", Seismic Certification and Analysis

B. All manufacturers, including Original Equipment Manufacturer (OEM), providing equipment and/or vibration/seismic control systems, must provide a Seismic Design Error and Omissions Insurance Certificate for their firm or their design consultant to certify their ability to provide engineering and design as required by this section.

C. All manufacturers of any type of equipment including Original Equipment Manufacturers (OEM) are responsible for Section 1.1.-1.6 including 1.3 Section "C", Seismic Certification and Analysis.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. All vibration isolators and seismic restraints described in this section shall be the product of a single manufacturer. The basis of this specification is Vibration Mountings & Controls.

Products from other nationally recognized manufacturers are acceptable provided their systems strictly comply with these specifications and have the approval of the specifying engineer. (See Form VL-1 listing other manufacturers to be considered for use on this project)

2.2 VIBRATION ISOLATION TYPES

A. Type A: Spring Isolator – Free Standing
VMC: ASC

1. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4" neoprene acoustical friction pad between the base plate and the support.

2. All mountings shall have leveling bolts that must be rigidly bolted to the equipment.
3. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load.
4. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.
5. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height.

B. Type B: Seismically Restrained Spring Isolator
VMC: AWRS, ASCM

1. Restrained spring mountings shall have a Type A spring isolator within a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of 1/4" shall be maintained around restraining bolts and internal neoprene deceleration bushings so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position there must be an internal isolation pad. Housing shall be designed to resist all seismic forces.

C. Type C: Combination Spring/Elastomer Hanger Isolator (30º Type)
VMC: RSH30

1. Hangers shall consist of rigid steel frames containing minimum 1 1/4" thick neoprene elements at the top and a steel spring with general characteristics as in Type A. The neoprene element shall have neoprene bushings projecting through the steel box.
2. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30º arc from side to side before contacting the rod bushing and short circuiting the spring.
3. Submittals shall include a hanger-drawing showing the 30º capabilities.
4. Hanger locations requiring pre-compression for holding piping at fixed elevation shall be type pre-compressed for all manufacturers.

D. Type D: Elastomer Double Deflection hanger Isolator
VMC: RHD

1. Molded (minimum 1 1/4" thick) neoprene element with projecting busing lining the rod clearance hole. Static deflection at rated load shall be a minimum of 0.35".
2. Steel retainer box encasing neoprene mounting capable of supporting equipment up to four times the rated capacity of the element.

E. Type E: Combination Spring/Elastomer Hanger Isolator
VMC: RSH

1. Spring and neoprene elements in a steel retainer box with the features as described by Type C and D isolators.
2. Hanger locations requiring pre-compression for holding piping at fixed elevation shall be type pre-compressed for all manufacturers.
3. 30º angularity feature is not required.

F. Type F: Seismically Restrained Elastomer Floor Isolator
VMC: RSM

1. Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2" and all directional seismic capability. The mount shall consist of a ductile iron or aluminum casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing specifications.

G. Type G: Pad Type Elastomer Isolator (Standard)
VMC: Maxiflex

1. One layer of 3/4" thick neoprene pad consisting of 2" square modules for size required.
2. Load distribution plates shall be used as required.
3. Bolting required for seismic compliance. Neoprene and duck washers and bushings shall be provided to prevent short-circuiting.

H. Type H: Pad Type Elastomer Isolator (High Density)
VMC: Fabriflex

1. Laminated canvas duck and neoprene, maximum loading 1000 psi, minimum 1/2" thick.
2. Load distribution plate shall be used as required.
3. Bolting required for seismic compliance. Neoprene and duck washers and bushings shall be provided to prevent short-circuiting.

I. Type I: Thrust Restraints
VMC: RSHTR

1. A spring element similar to Type A isolator shall be combined with steel angles, backup plates, threaded rod, washers and nuts to produce a pair of devices capable of limiting movement of air handling equipment to 1/4".

2. Restraint shall be easily converted in the field from compression type to tension type.
3. Unit shall be factory precompressed.
4. Thrust restraints shall be installed on all cabinet fan heads, axial or centrifugal fans whose thrust exceeds 10% of unit weight.

J. Type J: Pipe Anchors
VMC: MDPA

1. All-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum 1/2" thick 60 durometer neoprene.
2. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction.
3. Allowable loads on the isolation material should not exceed 500 psi and the design shall be balanced for equal resistance in any direction.

K. Type K: Pipe Guides
VMC: PG

1. Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" thickness of 60-durometer neoprene.
2. The height of the guides shall be present with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement.
3. Guides shall be capable of +/- 5/8" motion, or to meet location requirements.

L. Type L: Isolated Pipe Hanger System
VMC: CIH, CIR, TIH, PIH

1. Precompressed spring and elastomer isolation hanger combined with pipe support into one assembly. Replaces standard clevis, single or double rod roller, or double rod fixed support.
2. Spring element (same as Type A) with steel lower spring retainer and an upper elastomer retainer cup with an integral bushing to insulate support rod from the isolation hanger.
3. The neoprene element under the loser steel spring retainer shall have an integral bushing to insulate the support rod from the steel spring retainer.
4. Hangers shall be designed and constructed to support loads over three times the rated load without failure.
5. System shall be precompressed to allow for rod insertion and standard leveling.

2.3 SEISMIC RESTRAINT TYPES

A. Type I: Spring Isolator, Restrained
VMC: ASCM, AWR

1. Refer to vibration isolation Type B.

B. Type II: Seismically Restrained Elastomer Floor Isolator
VMC: RSM

1. Refer to vibration isolation Type F.

C. Type III: All-Directional Seismic Snubber
VMC: Type SR:

1. All-directional seismic snubbers shall consist of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing shall be replaceable and a minimum of 1/4 inch thick. Rated loadings shall not exceed 1000 psi. A minimum air gap of 1/8 inch shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Neoprene bushings shall be rotated to insure no short circuits exist before systems are activated.

D. Type IV: Floor or Roof Anchorage
VMC: FA

1. Rigid attachment to structure utilizing wedge type anchor bolts, anchored plates machine screw, bolting or welding. Power shots are unacceptable.

E. Type V: Seismic Cable Restraints
VMC: SCR

1. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of 2 and arranged to provide all-directional restraint. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize 2 clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Single arm braces with resilient bushings can be substituted for seismic cable restraints. Deck fittings shall have two through bolts spaced to ICBO standards for attachment to concrete.

F. Type VI: Rigid Arm Brace
VMC: SAB

1. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize 2 through bolts to provide proper attachment spaced to ICBO standards for attachment to concrete.

G. Type VII: Internal Clevis Cross Brace
VMC: ICB

1. Internal clevis cross braces at seismic locations shall be pre-cut pipe sized for internal clevis dimensions.

2.4 EQUIPMENT BASES

A. General

1. All curbs and roof rails are to be bolted or welded to the building steel or anchored to the concrete deck (minimum thickness shall be 4") for resisting wind and seismic load forces in accordance with the project location. (Fastening to metal deck is unacceptable.)

B. Base Types

1. Type B-1: Integral Structural Steel Base
VMC: WFB

a. Rectangular bases are preferred for all equipment.
b. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump for split case pump shall include supports for suction and discharge elbows.
c. All perimeter members shall be steel beams with a minimum depth equal to 1/12 of the longest dimensions of the base.
d. Base depth need not exceed 12" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer.
e. Height saving brackets shall be employed in all mounting locations to provide a minimum base clearance of 2".

2. Type B-2: Concrete Inertia Base
VMC: MPF

a. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations.
b. Bases for split case pumps shall be large enough to provide for suction and discharge elbows.
c. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6".
d. The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity.
e. Forms shall include minimum concrete reinforcing consisting of 1/2" bars welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom.
f. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured.
g. Height saving brackets shall be employed in all mounting locations to maintain a 2" minimum clearance below the base.
h. Flush profile wooden formed bases having correct depth and reinforcing requirements are acceptable.

3. Type B-3: Seismic Isolation Curb
VMC: P62/P6300 Sound package type VMC type RPFMA/SRPFMA

a. Curb mounted rooftop equipment shown on isolation schedule shall be mounted on structural seismic spring isolation curbs. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind and seismic forces. The lower frame must accept point support for both seismic attachment and leveling. The upper frame must be designed with positive fastening provisions (welding or bolting), to anchor the roof top unit to the curb, which will not violate the National Roofing Contractor's Association (NRCA) ratings of the membrane waterproofing. Sheetmetal screws are unacceptable. Contact points between the roof top unit, the curb and the building's structure shall show load path through those locations only.

b. All directional neoprene snubber bushings shall be a minimum of 1/4" thick. Steel springs shall be laterally stable and rest on 1/4" thick neoprene acoustical pads.
c. Hardware must be plated and the springs provided with a rust resistant finish.
d. The curbs waterproofing shall be designed to meet all NRCA requirements.
e. All spring locations shall have access ports with removable waterproof covers and all isolators shall be adjustable, removable and interchangeable.
f. The curb shall be the sound attenuating type utilizing standard 2" roof insulation supplied and installed by the roofing contractor to act thermally outside and acoustically inside. Curbs supplied without this feature shall be factory acoustically lined with 2" duct liner.

Option #1: Where sound barrier package is required, curb shall have full size lay in attenuation panels having a minimum STC rating of 60 when combined with the roof deck's rating. Attenuation system shall add a full sound attenuation structural floor to the curb capable of spanning the curb's width and designed for live loads of 20 psf. Panels shall not weigh more than 6 psf. The 4" nominal galvanized panel shall be joined allow for airtight construction and additionally shall have a support system where the panels are used below an outside condenser section. Panels shall be waterproof for both outdoor and indoor application. The space below the curb panels and the roof deck shall have 4" of insulation contractor furnished and installed.

Curb wall construction shall utilize the roofer's standard insulation where curbs use the TAS open thermal acoustical screening system. Solid wall curbs shall use 2" of factory ductliner installed by the curb manufacturer. The entire curb shall have a continuous neoprene air seal. Type RPFMA shall use an open return system with the roof return opening set as far as possible from the unit's return opening.

Option #2: When curb type SRPFMA (Supply Return Plenum Construction) is required, in addition to Option #1 the walls of the supply section will use 2" sound attenuating panels as well as a continuous inner neoprene air seal and isolated plenum divider. Both supply and return ducts shall seal directly to curb base floor attenuation panels.

4. Type B-4: Seismic Non-Isolated Curbs
VMC: P6000
Sound Package Type – VMC – RPFMA/SRPFMA System

a. These curbs shall have all provisions as Type B-3 curbs with the exception of spring isolation.

5. Type B-5: Isolated Equipment Supports
VMC: R7200/R7300

a. Continuous structural equipment support rails that combine equipment support and isolation mounting into one utilized roof flashed assembly with all features as described for Type B-3.
b. System shall be designed for positive anchorage or welding of equipment to supports and welding of supports to the building steel.

6. Type B-6: Non-Isolated Equipment Supports
VMC: R7000

a. This shall have the same provisions as Type B-5 without the spring isolation.

7. Type B-7: Computer Room Unit Base
VMC: CRC

a. Computer Room air conditioning units shall be welded or bolted to welded structural steel stands having a minimum 0.5 "G" certified lateral acceleration capabilities.
b. Non-isolated stand shall have 1" of adjustment to accommodate floor irregularities.
c. Bolting or welding required to meet seismic criteria.

2.5 FLEXIBLE CONNECTORS

A. Type FC-2: Flexible Stainless Steel Hose
VMC: BS

1. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" and larger shall be flanged. Smaller sizes shall have male nipples.

B. Type FC-2 connector shall be braided bronze for freon connections.

1. Minimum lengths shall be as tabulated:

FLANGED		MALE NIPPLES	
3 x 14	10 x 26	1/2 x 9	1 1/2 x 13
4 x 15	12 x 28	3/4 x 10	2 x 14
5 x 19	14 x 30	1 x 11	2 1/2 x 18
6 x 20	16 x 32	1 1/4 x 12	
8 x 22			

2. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible.

PART 3 - EXECUTION

3.1 GENERAL

A. All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

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

C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

D. The contractor shall not install any isolated equipment, piping or duct, which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.

E. Coordinate work with other trades to avoid rigid contact with the building.

F. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. General bracing may occur from flanges of structural beams, upper truss cords in bar joist construction and cast in place inserts or wedge type drill-in concrete anchors.

G. Seismic cable restraints shall be installed slighting slack to avoid short circuiting the isolated suspended equipment or piping.

H. Seismic cable assemblies are installed taut on non-isolated systems. Seismic solid braces may be used in place of cables on rigidly attached systems except where single arm braces incorporate resilient bushings.

I. At locations where seismic cable restraints or seismic sold braces are located the support rods must be braced when necessary to accept compressive loads.

J. At all locations where seismic cable braces and seismic cable restraints are attached to the pipe clevis, the clevis bolt must be reinforced with pipe clevis cross bolt braces or double inside nuts if required by seismic acceleration levels.

K. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted.

L. Where piping passes through walls, floors or ceilings, the contractor shall provide wall seals or resilient packed pipe sleeves.

M. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraints shall be those described in the specification when horizontal motion exceeds 3/8"

N. Special and Periodic Inspections for items listed in Section 1.3, Article 4 shall be conducted and submitted on a timely basis.

3.2 EQUIPMENT INSTALLATION

A. Equipment shall be isolated and restrained as per Tables A, B and C at the end of this section. Equipment determined by the Seismic Engineer of Record not to require seismic restraint shall still require being isolated with the appropriate vibration isolation; restraint will not be required.

B. Place floor mounted equipment on 4" high concrete housekeeping pads properly doweled or expansion shielded to the deck to meet acceleration criteria (see Section 1.4). Anchor isolators and/or bases to housekeeping pads. Concrete work is specified under Concrete in the specifications of the contract.

C. Additional Requirements

1. The minimum operating clearance under all isolated components bases shall be 2".
2. All bases shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the equipment, isolators and restraints.
3. The equipment shall be installed on blocks to the operative heights of the isolators. After the entire installation is complete, and under full operational load, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. Remove all debris from beneath the equipment and verify that there are no short circuits of the isolation. the equipment shall be free in all directions.
4. Ceilings containing diffusers must meet seismic zone requirements by using earthquake clips or other approved means of positive attachment to secure diffuser to T-bar structure.
5. All floor or wall mounted equipment and tanks shall be restrained with Type IV restraints.

3.3 PIPING AND DUCTWORK ISOLATION

A. Vibration Isolation of Piping

1. Water Piping: All spring type isolation hangers shall be precompressed if isolators are installed prior to fluid charge. If installed afterwards, standard, non-precompressed isolators can be used. All piping in the machine room shall be isolated as well as pressurized runs in other locations of the building 6" and larger. Horizontal pressurized runs in all other locations of the building shall be isolated by Type E hangers. Floor supported piping shall rest on Type B isolators. Heat exchangers and expansion tanks are considered part of the piping run. The first 3 isolators from the isolated equipment will have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces, the first 3 hangers shall have 0.75" deflection for pipe sizes up to and including 3", 1 3/8" deflection for pipe sizes thereafter. Where column spacing exceeds 35', isolation hanger deflection shall be 2-1/2" for pipes exceeding 3" diameter. Type L hangers may be substituted for the above where isolation hangers are required.

2. Steam and Condensate Piping: All ceiling suspended piping in the mechanical equipment room shall be isolated with Type D hangers. All floor supported piping shall be supported with Type F isolators.
3. Riser Location: All risers shall be supported on Type J or K anchors or guide restraints positive attached to both the riser and structure. Spiders welded to the pipe can substitute for Type K guides using J Type anchors.
4. Control Air Piping: Where control air piping is connected to mechanical piping equipment shall be flexibly connected in horizontal and vertical plane with Type FC-2 flexible connectors.

B. Seismic Restraint of Piping, Conduit, Bus Duct and Cable Tray

1. All high hazard and life safety pipe regardless of size such as fuel oil piping, fire protection mains, gas piping, medical gas piping and compressed air piping shall be seismically restrained. Type V seismic cables restraints or resilient single arm braces shall be used if piping is isolated. Type V seismic cable restraints or Type VI seismic solid braces may be used on unisolated piping. There are <u>no exclusions</u> for size or distance in this category.
2. Seismically restrain piping located in boiler rooms, mechanical equipment rooms and refrigeration equipment rooms that is 1 1/4" I.D. and larger. Type V seismic cables restraints or resilient single arm braces shall be used if piping is isolated. Type V seismic cable restraints or Type VI seismic solid braces may be used on unisolated piping.
3. Seismically restrain all other piping 2 1/2" diameter and larger. Type V seismic cables restraints or resilient single arm braces shall be used if piping is isolated. Type VI seismic cable restraints or seismic solid braces may be used on unisolated piping.
4. See Table D for maximum seismic bracing distances.
5. Multiple runs of pipe on the same support shall have distance determined by calculation.
6. Rod braces shall be used for all rod lengths greater than 3'.
7. Clevis hangers shall have spacers placed inside of hanger at seismic brace locations.
8. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.
9. For fuel oil and all gas piping, transverse restraints must be at 20' maximum and longitudinal restraints at 40' maximum spacing.
10. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24" of the elbow or TEE or combined stresses are within allowable limits at longer distances.
11. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints. Use Type V or VII restraint, if trapeze is smaller than 48" long.
12. Branch lines may not be used to restrain main lines.
13. All PVC and glass pipe less than 6" are braced only if the pipe use involves hazardous or toxic materials. All other PVC and glass pipe greater than 6" shall be braced at 20' transversely and 40' longitudinally with bottom shields.
14. Fire protection branch lines shall be end tied.

C. Vibration Isolation of Ductwork

1. All discharge runs for a distance of 50' from the connected equipment shall be isolated from the building structure by means of Type E combination spring/elastomer hanger or Type A floor spring isolators. Spring deflection shall be a minimum of 0.75".
2. All duct runs having air velocity of 1500 feet per minute (fpm) or more shall be isolated from the building structure by Type E combination spring/elastomer hangers or Type A floor spring supports. Spring deflection shall be a minimum of 0.75".

D. Seismic Restraint of Ductwork

1. Restrain rectangular ductwork with cross sectional area of 6 square feet or larger. Type V seismic cable restraints or Type VI seismic solid braces shall be used on this ductwork. Ductwork which serves a life safety function or carriers toxic materials must be braced.
2. Restrain round ducts with diameters of 28" or larger. Type V seismic cable restraints or Type VI seismic solid braces shall be used on this ductwork.
3. Retrain flat oval ducts the same as rectangular ducts of the same nominal size.
4. See Table D for maximum seismic bracing distances.
5. The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.
6. A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.
7. Walls, including gypsum board non-bearing partitions, which have ducts running through them, may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

COMPONENT EXCLUSIONS

Exclusions for equipment in states governed by UBC, IBC.

Component exclusions shall be designated by the current applicable Building Code, New York State and International Building Code reference ASCE Section 7 with modifications per Building Code.

COMPONENT EXCLUSIONS DO NOT APPLY TO THE FOLLOWING SERVICES

The following items do not qualify for any component exclusions, including but not limited to:

LIFE SAFETY or HIGH HAZARD

Life Safety or High Hazard equipment as listed in Section 1.1, C regardless of governing code for HVAC, Plumbing, Electrical or Fire Protection. *(A partial list is illustrated)* High Hazard is additionally classified as any system handling flammable, combustible or toxic material.

ELECTRICAL

Critical, standby or emergency power conduit (1" nominal diameter and larger), cable tray or bus duct, lighting, panel, communication lines involving 911, etc.

PIPING

Fuel oil, gasoline, natural gas, medical gas, steam, compressed air or any piping containing hazardous, flammable, combustible, toxic or corrosive materials. Fire protection standpipe, risers and mains. Branches must be end tied.

DUCT

Smoke evacuation duct or fresh air make up connected to emergency system, emergency generator exhaust, boiler breaching or as used by the fire department on manual override.

EQUIPMENT

Previously excluded non life safety duct mounted systems such as fans, variable air volume boxes, heat exchangers and humidifiers having a weight greater than 75 lbs. require independent seismic bracing

3.4 INSPECTION

A. All Independent Special and Periodic Inspections must be performed and submitted on components as outlined in Article 1.3, Section 4b.

B. Upon completion of installation of all vibration isolation devices, the local representative shall inspect the completed project and certify in writing to the contractor that all systems are installed properly, or require correction. The contractor shall submit a report to the Architect, including the representative's report, certifying correctness of the installation or detailing corrective work to be done.

HVAC EQUIPMENT TABLE "A"

		ON GRADE, BASEMENT OR SLAB ON GRADE					ABOVE GRADE			
EQUIPMENT (See Note!)		MTNG	ISOL	DEFL (in.)	BASE	RESTR	ISOL	DEFL (in.)	BASE	RESTR
Air Handling Units Indoor		Flr	B	0.75	---	IV	B	1.5	---	IV
		Clg	E	0.75	---	V	E	0.75	---	V
Dry Coolers Condensers/Condensing Outdoor Units		Roof	---	---	---	IV	B	2.50 (minimum)	B-5	IV
Base Mounted Pumps	To 15 HP	Flr	B	0.75	B-2	IV	B	0.75	B-2	IV
	>15 HP	Flr	B	0.75	B-2	IV	B	1.50	B-2	IV
Curb Mtd. Equip. (Non-Isol.)		Roof	---	---	---	IV	---	---	B-6	IV
Rooftop AHU/AC	< 10 Ton	Roof	---	---	---	IV	B	1.50	B-3 *(3,4)	IV
	> 10 Ton	Roof	---	---	---	IV	B	2.50	B-3 *(3,4)	IV

Minimum Deflection Guide for Table "A"

R.P.M.	DEFLECTION
Less than 400	3.50"
401 to 600	250"
601 to 900	1.50"
OVER 900	0.75"

Note for TABLES A, B:

GENERAL: ISOL = ISOLATOR, DEFL = DEFLECTION, RESTR = SEISMIC RESTAINT, MTNG = MOUNTING. ALL DEFLECTIONS INDICATED ARE IN INCHES.

Note 1: For equipment with variable speed driven components having driven operating speed below 600 rpm, select isolation deflection from minimum deflection guide.

Note 2: For roof applications, use base Type B-5.

Note 3: Curb Type B-3 shall use sound barrier RPFMA when there is no concrete under roof top units. Curbs can be used for return plenums. (See Option #1)

Note 4: Where curbs require supply and return sound attenuation package type SRRFMA shall be used. (See Option #2)

Engineers Note: Where Type 3 or 4 sound attenuation systems are used this note shall appear on equipment schedule.)

Note 5: Units may not be capable of point support. Refer to separate air handling unit specification section. If base is not provided by that section and external isolation is required, provide Type B-1 base by this section for entire unit.

Note 6: Static deflection shall be determined based on the deflection guide for Table "A".

Note 7: Deflection indicated are minimums at actual load and shall be selected for manufacturer's nominal 5", 4", 3", 2" and 1" deflection spring series, RPM is defined as the lowest operating speed of the equipment.

Note 8: Single stroke compressors may require inertia bases with thickness greater than 14" maximum as described for base B-2. Inertia base mass shall be sufficient to maintain double amplitude for 1/8".

Note 9: Floor mounted fans, substitute base Type B-2 for class 2 or 3 or any fan having static pressure over 5".

Note 10: Indoor utility sets with wheel diameters less than 24" need not have deflections greater than .75".

Note 11: Curb mounted fans with curb area less than 9 square feet are excluded.

Note 12: For equipment with multiple motors, Horse Power classification applies to largest single motor.

TABLE B

SEISMIC BRACING TABLE
(Maximum Spacing Shown – Actual Spacing to Be Determined by Calculation)

EQUIPMENT	ON CENTER TRANSVERSE	ON CENTER LONGITUDINAL	CHANGE OF DIRECTION
DUCT	30 FEET	60 FEET	4 FEET
PIPE THREADED, WELDED, SOLDERED OR GROOVED			
TO 16”	40 FEET	80 FEET	4 FEET
18” – 28”	30 FEET	60 FEET	4 FEET
30” – 40”	20 FEET	60 FEET	4 FEET
42” & LARGER	10 FEET	30 FEET	4 FEET

PIPE – NO HUB OR BELL AND SPIGOT			
2.5 & LARGER	10 FEET	20 FEET	4 FEET
CONDUIT	40 FEET	80 FEET	4 FEET

FORM CQAP

Section 23
Vibration Isolation and Seismic Restraints

Contractor Name: ________________________________

Date: ____

Project: ____

Specification Section: ___________________________

Contractor IBC Quality Assurance Seismic Program (Part of SGMEC) Specification

This form is to be filled out before the first submission in any vendor group by the installing contractor. All items listed herein shall be part of the contractor's quality assurance program.

1. Acknowledge special requirements contained in the quality assurance plan.
2. Acknowledge that control will be exercised to obtain conformance with the construction documents.
3. Procedures for exercising control within the contractor organization including frequency and distributions of inspections and testing reports.
4. Identification and qualification of the persons exercising control of this program within their organization.

Contractor to submit this program acknowledging receipt and program implementation. Each of the 4 (four) listed programs are to be submitted including all applicable details as listed above.

____
Signature

____
Print Name

FORM CVC-1

Section 23
Vibration Isolation and Seismic Restraints

Contractor Name: ________________________________

Date: ____

Project: ______________________________________

Specification Section: ____________________________

Notes to the Installing Contractor

The purpose of this form is for you the contractor to fill in all vendors that are IBC approved as part of your initial submission for any group of equipment, i.e., fans, ac units, pumps, etc. By identifying which of the vendors have IBC approval, both you and the project's specifying engineer are protected. Only IBC approved vendors can participate on this project. In the event that no vendor in any group has IBC certification than any vendor who meets the project's performance specifications is acceptable.

Note: The cutoff date for this requirement, for any vendor group, is the project's plan filing date for Code Review on this project.

MANUFACTURER	**YES**	**NO**

____
Signature

____
Print Name

FORM SQA-1

Section 23
Vibration Isolation and Seismic Restraints
Seismic Quality Assurance Plan for The Installation of Life Safety
And High Hazard Systems (Inspections)

Contractor Name: ________________________________

Date: ____

Project: ____

Specification Section: _____________________________

The following are required for the Seismic Quality Assurance Installation Plan for Life Safety and High Hazard Systems to be prepared and submitted by each installing contractor. This plan must reflect all of the provisions and reports outlined in the paragraphs below. As part of this contractor's final requisition, this form must accompany, along with all satisfactorily completed tests and reports, the final payments request including all applicable certification reports.

- Special field inspection and testing is required by IBC Sections 1704, 1707 and 1708 during the installation of Life Safety and High Hazard System components including equipment, piping and all electrical connections. Components must be inspected by a Building Official or approved independent special inspector periodically during the course of installation. Contractor shall submit such inspection reports as part of his project wrap up for each group of equipment, components so requiring this program. All components, which are Life Safety designate or Handle Hazardous substances, fall into this category. Typical Life Safety and High Hazard components as well as non-life safety components listed in that section, are outlined in Section 4 of the SGMEC® Specifications.

____
Signature

____
Print Name

END OF SECTION 23 05 48

SECTION 23 05 53 - IDENTIFICATION FOR HVAC

PART 1 - GENERAL

1.1 STIPULATIONS

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

1.2 WORK INCLUDED

A. This Section includes the following mechanical identification materials and their installation:

1. Equipment nameplates.
2. Pipe markers.
3. Duct markers.
4. Valve tags.

1.3 RELATED WORK

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

1.4 REFERENCES

A. ASTM C 1036-91 (Reapproved 1997): Specification for flat glass.

B. ASTM D 709-92 (Reapproved 1997): Specification for laminated thermo-setting materials.

C. ASME A13.1-96: Scheme for the identification of piping systems.

1.5 SUBMITTALS

A. Submit product data.

B. Submit list of wording, symbols, letter size and color coding for mechanical identification.

C. Submit valve chart and schedule, including valve tag number, location, function and valve manufacturer’s name and model number. (also include maintenance manuals)

D. Submit manufacturer’s installation instructions.

1.6 QUALITY ASSURANCE

A. ASME Compliance: comply with ASME A13.1, "Scheme for the Identification of Piping Systems", for letter size, length of color field, colors and viewing angles of identification devices for piping.

1.7 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Color: Unless specified otherwise, conform the ANSI/ASME A13.1.

B. Plastic Nameplates: Laminated three-layer plastic with engraved black letters on light contrasting background.

C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.

D. Plastic Pipe Markers: As indicated herein.

2.2 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:

a. Manufacturer, product name, model number and serial number.
b. Capacity, operating and power characteristics and essential data.
c. Labels of tested compliances.

2. Location: Accessible and visible.
3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.

1. Terminology: Match schedules as closely as possible.
2. Data:

   a. Name and plan number.
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters such as pressure drop, entering and leaving conditions and speed.
3. Size: 2-1/2 by 4 inches for control devices, dampers and valves; 4-1/2 by 6 inches for equipment.

C. Access Panel and Door Markers: 1/16-inch-thick, engraved laminated plastic with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment. Markers for chemical fume or bio-hazard service shall be labeled accordingly.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.3 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe markers, General: Preprinted, color-coded, with lettering indicating service and showing direction of flow.

1. Colors: Comply with ASME A13.1, unless otherwise indicated.
2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type markers at least three times letter height and of length required for label.
5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Pre-tensioned Pipe Markers: Pre-coiled semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

C. Shaped Pipe Markers: Preformed semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.

2.4 DUCT IDENTIFICATION DEVICES

A. Duct Markers: Engraved, color-coded laminated plastic. Include direction and quantity of airflow and duct service (such as supply, return and exhaust). Include contact-type, permanent adhesive. Markers for chemical fume or bio-hazard service shall be labeled accordingly.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by Architect. Provide 5/32-inch hole for fastener.

1. Material: 0.032-inch-thick brass.
2. Valve-Tag Fasteners: Brass S-hook.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 23 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Water source heat pumps.
2. Pumps, compressors, chillers, condensers, and similar motor-driven units.
3. Heat recovery units and similar equipment.
4. Fans.
5. Packaged roof top units.

B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.

1. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:

   a. Main control and operating valves, including safety devices and hazardous units.
   b. Meters, gages, thermometers, and similar units.
   c. Water source heat pumps.
   d. Heat recovery units and similar equipment.
   e. Fans.

f. Packaged roof top units.
g. Strainers, filters, and similar equipment.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation: Pre-tensioned pipe markers. Use size to ensure a tight fit.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior non-concealed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and non-accessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

3.4 DUCT IDENTIFICATION

A. Install duct markers with permanent adhesive on air ducts in the following color codes:

1. Green: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Blue: For exhaust-, outside-, return-, ducts.
4. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

3.5 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; and convenience 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:

1. Valve-Tag Size and Shape:

   a. Heating Water: 1-1/2 inches round.

2. Valve-Tag Color:

   a. Heating Water: Natural

3. Letter Color:

   a. Heating Water: Black.

3.6 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.7 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 23 05 53

SECTION 23 05 93 - TESTING, ADJUSTING AND BALANCE 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 WORK INCLUDED

A. The work included under this section of the specifications consists of the furnishing of all labor, materials, equipment and service necessary to complete the inspections, testing, guarantee and acceptance of all HVAC work as shown on the drawings and specified herein.

B. All work shall be tested to satisfaction of the Architect/Engineer, for leaks, faulty joints, improper operation and inefficiency.

C. Provide test pump, gauges, meters, other instruments, materials, and labor in connection with tests.

D. Do not cover or paint any part of piping or connect equipment, before testing and obtaining approval.

E. All equipment and piping shall be thoroughly cleaned of iron cutting and other refuse during assembly, installation and before testing.

F. The work included under this section of specifications also consists of the furnishing of all labor, materials, equipment and service necessary to perform air and water balancing for the HVAC work on water circulating systems, on hot water heating, chilled water, air distribution and exhaust systems as shown on the drawings and as called for in these specifications.

G. The balancing work shall include, but not be limited to the following items.

1. The setting and adjusting of all dampers and accessories to achieve proper air distribution and patterns in all parts of the air supply and exhaust systems.
2. The setting and adjusting of all belted fan speeds as may be required to attain proper total CFM deliveries.
3. The inspection of the function and operation of all ATC air and hydronic controls to insure proper operation and control cycles.
4. The setting and adjusting of all balancing cocks to attain the proper GPM deliveries in the various water piping systems.
5. Verify the setting and flow through all factory set automatic balancing air and water devices.
6. The setting and adjusting of all valves and pressure relief valves.

7. The measurement of feed water and transfer pump flows.
8. Submitting a report on each phase of the work.

1.3 RELATED SECTIONS

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Vibration Isolation

D. Division 23 – Hydronic Specialties

E. Division 23 – HVAC Commissioning

F. Division 23 – HVAC Pumps

G. Division 23 – Roof Top Units

H. Division 23 – Terminal Heat Transfer Units.

I. Division 23 – Power Ventilators

J. Division 23 – Ductwork

K. Division 23 – Ductwork Accessories

L. Division 23 – Air Terminal Units

M. Division 23 – Air Outlets and Inlets

N. Division 23 – Sequence of Operation

1.4 REFERENCES

A. AABC – Associated Air Balance Council – National Standards for Field Measurement and Instrumentation, Total System Balance.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 – "Air Balancing".

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 – "System Balancing".

D. NEBB – National Environmental Balancing Bureau – Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

E. TABB – Testing, Adjusting and Balancing Bureau.

1.5 SUBMITTALS

A. Quality-Assurance Submittals: Within 30 days from the Contractor's Notice to Proceed, submit two (2) copies of evidence that the testing, adjusting, and balancing Agent and this Project's testing, adjusting, and balancing team members meet the qualifications specified in the "Quality Assurance" Article below.

B. Certified Testing, Adjusting and Balancing Reports: Submit three (3) copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting and balancing Agent.

1.6 QUALITY ASSURANCE

A. The Contractor shall procure the services of an independent air balancing and test agency who shall not have any affiliation with construction contractors, equipment sales or design engineering firms.

B. The balancing agency shall specialize in the balancing and testing of heating, ventilating and air conditioning systems and shall provide proof of having successfully completed at least five projects of similar size and scope.

C. The testing and balancing agency shall be approved and acceptable to the Architect/Engineer and shall not be replaced without the written approval and consent of the Architect/Engineer. All field work shall be under the direct supervision of a registered professional engineer who is a full time employee of the balancing agency.

D. Submit biographic data on the balancing firm certification and certification of employees performing the work. Submit instrumentation types and proof of recent calibration. The instrumentation shall include electronic flow foods, meters that accept pressure measurement and/with temperature compensation and other such modern industry accepted instrumentation.

E. The testing and balancing agency shall be a certified member of the AABC, NEBB or TABB, unless otherwise approved.

1.7 PREPARATION FOR TESTING AND BALANCING

A. The balancing agency shall report to and review the work required with the Design Engineer before beginning field balance work. The balancing agency shall make at least two inspection of the air system during construction and shall report its findings in writing to the Design Engineer. Prior to start of balancing systems; submit to the Engineer written procedures on balancing procedures.

B. The balancing agency shall cooperate with the Design Engineer and the Contractor to effect smooth coordination of the balancing work with the job schedule. Final balancing shall be done at a time agreeable to the Architect.

C. The balancing agency shall be responsible for getting the various systems into proper operation. They shall enlist the aid of the ATC subcontractor, equipment suppliers, and Contractor as may be required to effect proper operation consistent with the Contract Plans and Specifications.

D. The Engineer shall have the option to spot check system balance and the balancing agency shall provide all equipment and labor as required.

1.8 JOB CONDITIONS

A. Air balance and testing shall not begin until system has been completed and is in full working order with the specified filters in place. Place all systems and equipment into full operations and continue the operation during each working day of testing and balancing.

B. Procedure and test shall be as specified. Procedure and test not specified shall be in accordance with Associated Air Balance Council publication, "National Standards for Field Measurements and Instrumentation, Total System Balance" and 2011 ASHRAE HVAC Applications Guide Chapter 57 "Testing Adjusting and Balancing."

C. Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.

D. The Contractor shall make any replacements in fan drive, sheaves and belts, and furnish additional dampers, balancing valves, cocks and fittings required for correct balance as required to meet design data.

E. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by the instrument manufacturer.

1.9 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting and balancing activities.

B. Notice: Provide 7 days advance notice for each test. Include scheduled test dates and times.

C. Perform testing, adjusting and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS

A. Not Applicable

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine project record documents described in Division 01 Section "Project Record Documents."

D. Examine Architect's and Engineer's 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 system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.

F. Examine system and equipment test reports.

G. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

H. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

I. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

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

K. Examine plenum ceilings, utilized for supply air, to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

L. Examine 3-way valves for proper installation for their intended function of diverting or mixing fluid flows.

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

N. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices operate by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multi-zone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
5. Thermostats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to design values.

O. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.2 GENERAL PROCEDURES

A. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.

B. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.3 AIR DISTRIBUTION TEST AND BALANCE

A. All filters shall be clean and in place before starting fans. All air filters shall be artificially loaded by partial blanking or other means to produce air pressure drop midway between clean and dirty as specified. Controls and dampers shall be set for normal full air flow testing and balancing.

B. During testing and balancing period, all supply, return and exhaust air fans shall have speeds adjusted and drives changed where necessary so that fans deliver design CFM at the actual static pressure developed by the installed system. Increasing static pressure by dampering at fan or closing all volume dampers to induce system static will not be permitted. External static pressure noted in schedules on drawings included drops through duct systems, terminal units and diffusers. Total static pressures must be calculated by adding pressure drops through unit mounted coils and dirty filter conditions, and unit conversion losses if applicable to that of the previously mentioned components. Provide minimum one (1) fan sheave and drive change per fan system.

C. Adjust all air ducts to proper design CFM. Air quantities shall be adjusted by volume or splitter dampers. Dampers and other balancing devices shall have their adjusted positions marked in an inconspicuous permanent manner.

D. Test and adjust each diffuser, grille, and register within plus or minus 10 percent of design CFM requirements, but total air for each system shall be not less than indicated. Volume adjusters may be used to balance air quantities at outlets and inlets providing final adjustments do not produce objectionable drafts or sound levels in excess of specified limits. Design positive and negative pressure in each area must be maintained.

E. Diffusers, register, grilles, shall be adjusted to minimize drafts in all areas.

F. Diffusers, registers, grilles, shall be identified on test report as to location and areas.

G. Reading and test of diffusers, registers, shall include required FPM velocity and test resultant velocity, required CFM and test resultant CFM after adjustments.

H. Record design and test CFM, static pressure, motor voltage and amps (nameplate and test) for each fan.

I. Record design and test static pressure, in order of physical arrangement, for each system component, i.e., louver, filter, cooling coil, fan heating coil, etc., and the most remote terminal unit.

J. With controls functioning properly water flow rates, test and record air dry bulb for supply air, and air entering and leaving each coil. Where feasible, measure air dry bulb and wet bulb temperatures with the mechanically aspirated psychrometer.

K. Air distribution test and balance report shall include:

1. Schematic diagram of each system showing size and CFM (design and actual) for main ducts; all dampers and regulating devices; terminal units; and each inlet and outlet with design and actual CFM.
2. Test data form for each fan .
3. Tabulation of design, preliminary and final CFM for each diffuser, register, mixing box or other terminal. Summary of CFM tabulations by systems and comparison with respective fan data.

L. Automatically operated dampers shall operate as specified or indicted. Testing agency shall check all controls that regulate air flow and pressure for proper calibrations and list controls requiring adjustment.

M. As determined by the Engineer, for 10 percent of total rooms, tests and record hourly for four hours, the following:

1. Room design condition D.B. Heating and Cooling and W.B. cooling.

2. Room actual condition D.B. Heating and Cooling and W.B. cooling.

N. For variable-air volume systems, develop a plan to simulate diversity.

O. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

P. Check the airflow patterns from the outside-air louvers and dampers and the return and exhaust air dampers, through the supply-fan discharge and mixing dampers.

Q. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

R. Verify that motor starters are equipped with properly sized thermal protection.

S. Check dampers for proper position to achieve desired airflow path.

T. Check for airflow blockages.

U. Check for proper sealing of air-handling unit components.

V. Compensating for Diversity: When the total airflow of all terminal units is more than the fan design airflow volume, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the design airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

3.4 WATER TEST AND BALANCE

A. Preparation: Prepare water systems for balancing in the following manner:

1. Open all valves to full open position.
2. Assure that all strainers have been cleaned.
3. Examine water in system. If dirty or untreated, drain system, and refill with clean treated water.
4. Check pump rotation and correct if necessary.
5. Check expansion tanks to determine that they are not air-bound or water-bound and that system is completely full of water.
6. Check all air vents at high points on water systems and determine all are installed and operating freely.
7. Set all temperature controls so coils are calling for full cooling. This should close all automatic bypass valves at coil and converters. Same procedure when balancing hot water coils, set on full call for heating.
8. Check operation of automatic bypass valve.
9. Complete air balance must have been accomplished before actual water balance begins.
10. Automatically operated valves shall operate as specified or indicated. Testing agency shall check all controls that regulate hydronic flow and pressure for proper calibration and list controls requiring adjustment.

B. Adjustment: Proceed as follows:

1. Set pumps to proper gallons per minute delivery.

2. Adjust water flow.
3. Check leaving water temperatures and return water temperatures. Reset to correct design temperature.

4. Check water temperature at inlet side of coils. Record rise or drop of temperatures from sources.
5. Proceed to balance each coil.

C. Readjustment: Proceed as follows:

1. After adjustment to coils are made, recheck settings at pump and readjust if required.
2. Install pressure gages on coil, read pressure drop through coil at set flow rate on call for full cooling and full heating. Set pressure drop across bypass valve to match coil full flow pressure drop. This prevents unbalanced flow conditions when coils are on full bypass.
3. Check record and include in the test report the following items.

   1) After adjustments to coils are made, recheck settings at pump and readjust if required.
   2) Install pressure gages on coil, read pressure drop through coil at set flow rate on call for full cooling and full heating. Set pressure drop across bypass valve to match coil full flow pressure drop. This prevents unbalanced flow conditions when coils are on full bypass.
   3) Check record and include in the test report the following items.

      a) Inlet water and air temperatures (dry bulb and wet bulb) at each coil.
      b) Leaving water and air temperatures (dry bulb and wet bulb) at each coil.
      c) GPM and pressure drop at each coil, heat exchanger, boiler, chiller and other similar devices.
      d) Pressure drop across each coil bypass where obtainable.
      e) Operating suction and discharge pressures and final T.D.H. for each pump.

   4) List all mechanical specifications of pumps; pump head, gpm and horsepower.
   5) List rated and actual running amperage of pump motor.
   6) Check water metering device readings.

3.5 TEST AND BALANCE REPORTS

A. All tests and balance reports and other requirements of this section will be completed and furnished to Engineer prior to Final Inspection. Submit four copies. Use format similar to forms of Sheet Metal & Air Conditioning Contractors Association, Inc., Washington, D.C., or Associated Air Balance Council, Los Angeles, California.

B. Types, serial numbers, and date of calibration of all instruments shall be included.

C. Reports shall identify conspicuously items not conforming to contractor requirements, or obvious maloperation and design deficiencies.

3.6 MARKING OF SETTINGS

A. Following final acceptance of Certified Reports by the Architect, the setting of all valves, dampers and other adjustment devices shall be permanently marked by the Contractor, so that adjustment can be restored if disturbed at any time. Devices shall not be marked until after final acceptance.

B. Marking of the set point shall be with an arrow indicator. Method shall be by stamping or cutting the balance post or lever. A water proof marker may be used for indication on non wear surfaces.

C. Temporary marks shall be used during rough balance and before approval of the balance report for reference. Temporary marks shall be removed upon final marking.

3.7 PIPING SYSTEMS TESTS

A. Pressure tests shall be performed on all piping before equipment is hooked up to the piping.

B. Refer to Division 23 Piping Specifications for requirements.

3.8 SPECIAL TESTING

A. Test and set relief valves to specified relief pressure. Test and adjust pressure reducing valves to specified reduced pressure. Test and adjust meters and other instruments, after installation, to assure accurate operation. Replace all gauges and thermometers that are out of calibration.

3.9 ADJUSTMENTS, REPAIRS AND RETESTS

A. Adjust, repair and retest the systems as specified herein.

B. Correct defects disclosed by tests or inspection; replace defective parts when directed. In replacing defective parts, use only new material; in the case of pipe replace with same length as defective piece. Caulking of screwed joints and peeling of welds will not be permitted. Repeat tests after defects have been corrected and part replaced, as directed until pronounced satisfactory.

C. The cost of repairs and restoration of work of other trades damaged by tests, or cutting that had to done in connection with test, shall be made at no extra cost to the Owner.

3.10 OIL AND SERVICING

A. All bearings and packing glands shall be properly protected during installation. Before the equipment is placed in operation, they shall be filled with the type of lubricant recommended by the manufacturer of the apparatus. Prior to final acceptance all equipment flanks shall be repacked and all valve packing glands tightened.

B. At completion of the work, prior to is operation by the Owner, all overload devices in motor starters shall be replaced or adjusted as required for proper operation of the motors. All damage to materials, equipment or finish of any part of the work resulting from the final adjusting of the equipment all be repaired to match the new condition of work.

C. All such repairs shall be the responsibility of the contractor who shall have mechanics of the trade who originally installed the work make the repairs.

3.11 PERFORMANCE TESTS AND ACCEPTANCE

A. Before final acceptance of the HVAC system, the contractor shall test the HVAC systems under normal conditions for two 8-hour days or longer when so directed to determine that they fulfill requirements of plans, specifications and that they operate satisfactorily.

B. Contractor shall cooperate with the temperature control manufacturer to integrate the control system with the HVAC system.

C. Heating system operating test shall be made during the heating season of the first year of operation at time when directed, for proper setting and adjustment of control under peak load conditions.

D. Air condition operating test shall be made during the summer months of the first year of operating at time when directed for proper setting and adjusting of controls under peak load conditions.

E. Contractor shall subject ventilating systems to operating tests for a period of two hours minimum for each system to demonstrate that each complied with the requirements of plans and specifications, that controls are functioning properly, and equipment operates satisfactorily.

F. Any defects made manifest by those tests shall be immediately and promptly made good after which the system shall be retested as required and/or directed.

G. Under no conditions will final payment be considered until results of all tests and adjustments have been submitted to and approved by the Architect.

3.12 INSPECTION

A. This contractor shall obtain all inspections required by laws, ordinances, rules and regulations of State, Local authority having jurisdiction, and he shall obtain certificates of such inspections and submit them to the Architect and shall pay all fees, charges, and other expenses in connection with the same, and include same in contract price.

B. This contractor shall furnish and install such test fees and plug fittings in his work as may be required by local authorities for their test and any other test required and shall ascertain information from local authorities as to all requirements before installation of work. No claims for extension of time will be entertained which arise from failure to obtain this information in time, or securing the necessary permits and arranging for required inspection.

3.13 ACCEPTANCE TESTING

A. An acceptance test of the HVAC system shall be performed by the Contractor in the presence of the Owner's representative and the Local Fire Marshal. Upon completion of the successful test, the Contractor shall so certify in writing to the Owner and General Contractor.

B. The Contractor shall also utilize all sub-contractors such as sheetmetal, balancing, piping, controls and commissioning agent, and other contractors such as electrical, plumbing, fire alarm and communications as required to perform this acceptance test.

C. The acceptance test shall be performed to determine that the protective measures required as outlined in NFPA 90A and shall function when needed in order to restrict the spread of fire and smoke.

D. The acceptance test shall include testing the HVAC system to determine its full functionability and in compliance with NFPA 90A and the sequence of operation. All controls and equipment shall be modulated throughout their entire ranges and adjustments shall be made for optimum performance.

1. Portions of control or alarm systems are permitted to have standby power or other emergency modes of operation.
2. The tests shall be performed to determine that the system operates under the standby power or emergency operation mode as well as under normal conditions.

E. All fire, smoke, combination fire/smoke dampers and ceiling dampers shall be operated and tested by Contractor prior to occupancy of a building to determine that they function in accordance with NFPA 90A, compliance report must be forwarded to Engineer and Owner.

END OF SECTION 23 05 93

SECTION 23 07 13 - DUCT INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Ductwork insulation.

B. Insulation jackets.

C. Acoustical insulation.

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

1.3 REFERENCES

A. ANSI/ASTM C533 – Calcium Silicate Block and Pipe Thermal Insulation.

B. ANSI/ASTM C534 – Flexible Elastomeric Cellular Thermal Insulation.

C. ANSI/ASTM C612 – Mineral Fiber Blocks and Board Thermal Insulation.

D. ASTM E84 – Surface Burning Characteristics of Building Materials.

E. NFPA 255 – Surface Burning Characteristics of Building Materials.

F. UL 723 – Surface Burning Characteristics of Building Materials.

G. International Energy Conservation Code latest edition.

H. Energy Conservation Construction Code of New York State, latest edition.

I. ASHRAE 90.1 latest edition.

1.4 QUALITY ASSURANCE

A. Applicator: Company specializing in ductwork insulation application with five (5) years minimum experience of projects of similar size and scope.

B. Materials: UL listed; frame spread/smoke developed rating of 25/50 or less in accordance with ASTM E84.

1.5 SUBMITTALS

A. Submit product data under provisions of Division 23 – Basic Mechanical Requirements.

B. Include product description, list of materials and thickness for each service, and locations.

C. Submit sound transmission loss for 125 to 4000 Hz frequencies on Type D insulation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURES – INSULATION

A. Owens-Corning

B. Johns Manville

C. Certainteed

D. Knauf

E. Armacell

F. Thermal Ceramics

2.2 MATERIALS

A. Type A: Flexible glass fiber; ANSI/ASTM C553 and ASTM C 1290; commercial grade; "k" value of 0.29 at 75 degrees F; rated to 250 degrees F; 3/4 lb. density; foil scrim kraft facing for air conditioning ducts. Manville R Series Microlite (Basis of Design).

B. Type B: Rigid glass fiber; ANSI/ASTM C612, Class 1; "k" value of 0.24 at 75 degrees F; 3 lb./cu. ft. density; rated to 350 degrees F; foil scrim facing for air conditioning ducts. Manville Spin-Glass Board (Basis of Design).

C. Type C: Flexible glass fiber; ANSI/ASTM C553; "k" value of 0.24 at 75 degrees F; 3 lb./cu. ft. minimum density; coated air side for maximum 4,000 ft./min. air velocity. Manville Linacoustic RC (rectangular), Spiracoustic Plus (round).

		Sound Absorption Coefficients						
Type Duct	**Thickness**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**NRC**
Rectangular	1"	.08	.31	.64	.84	.97	1.03	.70
Rectangular	2"	.25	.66	1.00	1.05	1.02	1.01	.95
Round	1"	.05	.21	.71	1.01	1.07	1.04	.75
Round	2"	.17	.63	1.10	1.05	1.04	1.06	.95

D. Type D: HUSHCORE™ *Deck*™ System In-Curb Multi-Layer Acoustical Treatment

1. HUSH BATT™ HBNF-400 acoustical batt.

   a. Shall be installed on the deck using a double layer
   b. Seams in each layer shall be staggered
   c. Shall be manufactured from 80% post-consumer recycled content
   d. Shall be 100% recyclable
   e. Shall be treated with EPA approved mold, bacteria and fungi inhibitor
   f. Shall have a thermal value of R-13 for each 4" thick layer
   g. Shall meet Class "A" per ASTM E84 for flammability

2. HUSHCORE™ BUB-755 acoustical composite

   a. The composite shall meet ASTM E-84 Class "A" for flammability.
   b. The composite panels shall get HUSH SEALANT™ acoustical grade caulk at seams and all perimeter edges inside the curb
   c. A single layer of BUB-755 shall be installed on top of the two layers of HUSH BATT™. All layers shall have staggered seams.

3. HUSH SEALANT™ HSAC-100 acoustical caulk

   a. Shall be a non-hardening formulation
   b. The acoustical sealant must be applied around the entire perimeter of the curb, around duct drop penetrations of the decking, and at all seams between BUB-755 composite panels.

4. The overall installed thickness shall be 10".
5. BRD Noise and Vibration Control, as Basis of Design.
6. Exceptions must be submitted and approved prior to project bid date as "or equal" compliant.
7. HUSHCORE™ In-Curb Acoustic Treatment Acoustical Performance

   a. The combination of all layers shall be tested for Sound Transmission Loss in accordance with procedure ASTM E-90-10. The assembly shall be rated at not less than STC-52 with 1/3 octave performance values as listed below for sound radiation through the deck inside the curb.

Freq. (Hz)	80	100	125	160	200	250	315	400	500	630	800	1K
TL (dB)	26	27	33	32	35	42	45	45	50	56	59	60
Freq. (Hz)	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	STC	
TL (dB)	62	63	64	65	67	71	74	78	80	80	52	

E. Type E: Flexible elastomeric rubber; ASTM C534, 0.08 perm-in water vapor permeability; 0.28 “k” valve of 0.25 at 75 degrees F; 25/50 flame/smoke developed rating per ASTM E84. Armacell AP/Armaflex as Basis of Design.

F. Type F: Mineral wool; 0.25 “k” value at 70 degrees F: 2000 degrees F service temperature; zero inch to combustibles 0/0 flame/smoke spread per ASTM E84: 2 pcf density; unfaced batts. Moisture Resistance – less than 0.03% by volume per ASTM C1104. ASTM C665 corrosion resistance compliance. Zero mold growth per ASTM C1338. Environmental Product Declaration (EPD): UL certified EPD in accordance with EN 15804 and ISO 14025. Greenguard Gold Certified. Johns Manville TempControl Batts or Rockwool Comfort Batt.

G. Type G: Rigid polyisocyanurate foam; ANSI/ASTM C1289 and ASTM C236/C518 0.14 “k” value at 75 degrees F. Closed-cell polyisocyanurate foam core with continuous sheet of aluminum foil face on one side and three-ply laminate of kraft and aluminum foil on the other. DOW TUFF-R (Basis of Design).

H. Adhesives: Waterproof (fire-retardant) type.

I. Finishing Cement: Fire resistive to ASTM E84.

J. Joint Tape: Foil backed.

K. Tie Wire: Annealed steel, 16 gage.

L. Glass Cloth Jacket: MIL-C-20079H, plain weave, 8 oz/sq yd.

M. Aluminum Jackets: ASTM B209; 0.020 inch thick; smooth finish.

N. EPDM Jackets – 0.060" thick, adhered, Mule-Hyde.

PART 3 - EXECUTION

3.1 DECKING

A. Decking shall be maintained inside the RTU roof curb to a clearance of ¼” maximum around all duct drops but never contact the duct.

1. Pack all air gaps around duct drops for return and supply with HBNF-400 and seal with HUSH SEALANT™ HSAC-100.

3.2 INSPECTIONS

A. The manufacturer or their local authorized agent shall inspect the in-curb deck system work on site prior to lowering of the units and issue a letter of certification stating that the products have been properly installed and sealed around all ductwork and drops to eliminate air gaps which can compromise performance.

3.3 PREPARATION

A. Install materials after ductwork has been tested and approved.

B. Clean surfaces for adhesives.

3.4 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each duct system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attach insulation or jacket in either wet or dry state.

D. Apply multiple layers of insulation with longitudinal and end seams staggered.

E. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

F. Keep insulation materials dry during application and finishing.

G. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

H. Apply insulation with the least number of joints practical.

I. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

J. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

K. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

M. Install vapor-retarder mastic on ducts and plenums scheduled to receive vapor retarders.

1. Ducts with Vapor Retarders: Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.
2. Ducts without Vapor Retarders: Overlap insulation facing at seams and secure with outward clinching staples and pressure-sensitive tape having same facing as insulation.

N. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

1. Seal penetrations with vapor-retarder mastic.
2. Apply insulation for exterior applications tightly jointed to interior insulation ends.
3. Seal insulation to roof flashing with vapor-retarder mastic.

O. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

P. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.+

Q. Insulate diffuser plenums and housings with Type A or B, 2” thickness in a neat manner with vapor barrier jacket and continuous insulation from flex duct to diffuser at ceiling.

3.5 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Provide insulation with vapor barrier when air conveyed may be below 60 deg. F. All supply air ductwork throughout shall be insulated with the minimum 1 ½” insulation, type A, unless specifically scheduled. (See 3.5 Schedule)

C. Continue insulation with vapor barrier through penetrations.

D. Where intended lining is used, external insulation may be deleted unless indicated otherwise. Internal insulation shall be of sufficient thickness/R-Value to comply with the energy code where external insulation is deleted.

E. Insulate outdoor ductwork externally even if insulated internally.

F. Duct work insulation that is exposed in occupied spaces, shall have an <u>additional</u> layer of Kraft paper jacket with vapor sealing tape and/or an 8 oz./sq. yd. canvas cloth wrap, glued with two coats of sizing. Finish by painting with two coats of latex based paint. Color to be selected by Architect.

G. Type A Application

1. Secure insulation with vapor barrier on all ductwork and conveying components with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.

2. Secure insulation without vapor barrier with staples, tape or wires.
3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners when necessary to prevent sagging. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

H. Type B Application

1. Secure insulation with mechanical fasteners on 15 inch centers. Butt all joints tight.
2. On insulation with vapor barrier, cover all mechanical fasteners and joints with foil back adhesive tape.
3. On non-vapor barrier ducts, use plain white facing on insulation.
4. On exterior applications, finish with .060" thick "Mule-Hyde", EPDM top jacket.
5. Duct work insulation that is exposed in occupied spaces, shall have an <u>additional</u> layer of Kraft paper jacket with vapor sealing tape and/or an 8 oz./sq. yd. canvas cloth wrap, glued with two coats of sizing. Finish by painting with two coats of latex based paint. Color to be selected by Architect.

I. Type C Application

1. Adhere insulation with adhesive for 100 percent coverage. Secure insulation with mechanical fasteners on 15 inch centers maximum on top and side of ductwork where dimension exceeds 20 inches. Seal and smooth joints. Do not use nail-type fasteners. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
2. Ductwork dimensions indicated are net inside dimensions required for air flow. Increase ductwork to allow for insulation thickness.
3. Use galvanized sheet metal nosing at the beginning of each lined run.
4. Refer to Division 23 Section “Ductwork” for the double wall ductwork specifications and requirements.
5. Provide internal liner downstream of VAV boxes or other air control devices (including upstream of exhaust valves). Eliminate internal liner in healthcare/hospital applications.

J. Type D Application

1. Mechanically fasten double composite to 20-gauge sheetmetal backing and line all inside faces of roof curb. Also, lay within roof curb. (2 layers)
2. Use double composite with (2) layers of drywall for enclosure below rooftop unit. Materials and labor by General Contractor.

K. Type E Application

1. Apply in sheets; adhered 100% coverage to ductwork after ductwork has been cleaned as per manufacturer's recommendations to duct with all edges butted and joints. Overlap joints for installation of multiple layers.

L. Type F Insulation

1. Do not compress insulation to fit in spaces.
2. Fit insulation closely around electrical boxes, pipes, ducts, fumes and other projects in or passing through insulation.

3. Keep insulation minimum 3” from heat emitting devices such as recessed light fixtures and minimum 2” from sidewalls of chimneys and vents.

M. Type G Application

1. Apply in sheets; adhered 100% coverage to ductwork after ductwork has been cleaned as per manufacturer's recommendations with all edges butted and joints. Overlap joints for installation of multiple layers.

3.6 SCHEDULE

DUCTWORK	TYPE	MINIMUM THICKNESS (Inch)*	MINIMUM INSTALLED R-VALUE
Supply & Return Air Duct (Mechanical Rooms)	B	2.0	R-8
Supply and Return Air Duct (Outdoor)	G	2.0	R-12
Supply Air Duct (Exposed in Conditioned Space)	B	1.5	R-5
Supply & Return Air Duct (Unconditioned Concealed)	A	2.0	R-6
Supply & Return Air Duct in Shaft on Outside Wall or Ceiling w/Roof above	A or B	2.0	R-8
Supply Air Duct** (Return Air Plenum and other non-exposed areas)	A	1.5	R-6
Outside Air Intake	E	2.0	R-7
Back of Diffusers in Areas of Ducted Return	A or B		
Internal Acoustical Lining	C	2.0	R-5
Plenums	B	2.0	R-6
Board Below Roof Mounted Unit	D	4.0	N/A
Exhaust Duct (Outdoor)	None	EPDM Jacket Only Ventureclad 1577CW not acceptable	
All Ductwork not initiated to be insulated within which penetrates the building Envelope. ***	A	1.5	R-5
Duct Penetrations through the building exterior.	F	3.0	R-12

*Listed thickness is the minimum thickness commonly available. Provide insulation with greater thickness, if required, to meet the installed R-Value. Insulation thickness less than listed must get approval for use from the engineer.

** Supply Air Ducts within Return Air Plenums or Supply Air Ducts not insulated/described within Schedule shall receive insulation as indicated herein: Type A, 1.5, R-5.

***Insulation shall extend from the exterior penetration to 5'- 0" into the building interior.

END OF SECTION 23 07 13

SECTION 23 07 19 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Piping insulation.

B. Jackets and accessories

1.2 RELATED WORK

A. Division 23 – HVAC Scope of Work

B. Division 23 – Common Work Results for HVAC

1.3 REFERENCES

A. ANSI/ASTM C195 – Mineral Fiber Thermal Insulation Cement.

B. ANSI/ASTM C533 – Calcium Silicate Block And Pipe Thermal Insulation

C. ANSI/ASTM C547 – Mineral Fiber Preformed Pipe Insulation.

D. ANSI/ASTM C552 – Cellular Glass Block and Pipe Thermal Insulation.

E. ANSI/ASTM C534 – Flexible Elastomeric Cellular Thermal Insulation.

F. ASTM B209 – Aluminum and Aluminum-Alloy Sheet and Plate.

G. ASTM C449 – Mineral Fiber Hydraulic-setting Thermal Insulating and Finishing Cement.

H. ASTM E84 – Surface Burning Characteristics of Building Materials.

I. NFPA 255 – Surface Burning Characteristics of Building Materials.

J. UL 723 – Surface Burning Characteristics of Building Materials.

K. International Energy Conservation Code latest edition.

L. Energy Conservation Construction Code of New York State, latest edition.

M. ASHRAE 90.1, latest edition.

1.4 QUALITY ASSURANCE

A. Applicator: Company specializing in piping insulation application with five (5) years minimum experience of projects of similar size and scope.

B. Materials: Flame spread/fuel contributed/smoke developed rating of 25/50 in accordance with ASTM E84.

1.5 SUBMITTALS

A. Submit product data under provisions of Division 23 – Common Work Results for HVAC.

B. Include product description, list of materials and thickness for each service, and locations.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Owens-Corning

B. Johns Manville

C. Certainteed

D. Armacell

E. Pittsburgh Corning

F. Knauf

2.2 INSULATION

A. Type A: Glass fiber insulation; ANSI/ASTM C547; "k" value of 0.24 at 75 degrees F; noncombustible.

B. Type B: Elastomeric rubber; ANSI/ASTM C534; rigid closed cell; maximum water vapor transmission rating of 0.01 perms; "k" value 0.25 at 75 degrees F. Armacell AP/Armaflex as Basis of Design.

C. Type C: Elastomeric rubber; ANSI/ASTM C534; rigid closed cell; maximum water vapor transmission rating of 0.01 perms; "k" value 0.25 at 75 degrees F. Armacell AP/Armaflex as Basis of Design.

D. Type D: Rigid closed cell; all glass structure; ANSI/ASTM C552; "k" value of .35 at 75 degrees F; maximum water vapor transmission rating of .0005 perms; non-combustible; 8.5 pcf density. Pittsburgh Corning Foamglass.

2.3 JACKETS

A. Interior Applications

1. All Service Jackets: Kraft reinforced foil vapor barrier with self-sealing adhesive joints.
2. PVC Jackets: One piece premolded type. PVC jackets not allowed in return air plenums unless ASTM E84 25/50 rated.
3. Glass Cloth Jacket: MIL-C-20079H, plain weave, 8 oz/sq yd.

B. Exterior Applications

1. Aluminum Jackets: ASTM B209; 0.020 inch thick; smooth finish.

2.4 ACCESSORIES

A. Metal Jacket Bands: 3/8 inch wide; 0.15 inch thick aluminum.

B. Adhesives: Compatible with insulation.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install materials after piping has been tested and approved.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Continue insulation through all penetrations including roofs, floors and walls.

C. In exposed piping, locate insulation and cover seams in least visible locations.

D. Provide an insert, not less than 6 inches long, of same thickness and contour as adjoining insulation, between support shield and piping, but under the finish jacket, on piping 2 inches diameter or larger, to prevent insulation from sagging at support points. Inserts shall be cork or the heavy density insulating material suitable for the planned temperature range. Factory fabricated inserts may be used.

E. Neatly finish insulation at supports, protrusions and interruptions. Insulate over heat traced sections of pipe, provide heat transfer compound.

F. Jackets

1. Indoor, Concealed Applications: Insulated pipes conveying fluids above ambient temperature shall have all service jackets, factory-applied. Insulate fittings, joints, and

valves with molded insulation of like material and thickness as adjoining pipe, and finish with PVC jackets.

2. Indoor, Cold Applications: Insulated pipes conveying fluids below ambient temperature shall have vapor barrier jackets, factory-applied. Insulate fittings, Joints, and valves with molded insulation of like material and thickness as adjacent pipe and finish with PVC jackets. Leave no metal surfaces exposed.
3. Exterior Applications: Provide all service jackets with aluminum jacket with seams located on bottom side of horizontal piping. Insulate fittings, joints and valves with insulation of like material and thickness as adjoining pipe, and finish with aluminum jackets. Cover small areas of exposed insulation with Manville Insulkote primer and finish coating.
4. Calcium Silicate: Glass cloth jacket on indoor insulation. Use aluminum jacket on outdoor insulation.
5. PVC Jackets: Factory preformed, 30 mil thickness, UV resistant, noncombustible and 25/50 rated as per ASTM E84, nonconductive. Manville Zeston 2000 PVC. Secure with solvent adhesive. Cover joints and fittings with preformed PVC covers.

3.3 SCHEDULE: TYPE AND JACKET

PIPING	TYPE	VAPOR BARRIER
Glycol Piping (Indoor)	A	YES
Heating Water Supply and Return	A	NO
Cold Condensate Drains	A	YES
Refrigerant Suction	B	YES
Refrigerant Hot Gas	A	YES
Pumped Condensate Return	A	NO
Glycol Piping (In Mechanical Rooms)	C	YES
Glycol Piping (Outdoors)	D	YES
Chilled Water Piping (Outdoors)	D	YES
Chilled Water Piping (Indoors)	A	YES

SCHEDULE: THICKNESS

MINIMUM PIPE INSULATION ****

INSULATION THICKNESS FOR PIPES SIZES

		Pipe Size					
Piping System Types	Fluid Temperature Range	Runouts* Less Than1 in.	Less than 1 in.	1 - <1-1/2 in.	1-1/2 - < 4 in.	4 - <8 in	8 in. & Larger
<u>Hot Temperature Piping</u> High Pressure Steam, Hot Water or other fluid	>350	4.5	4.5	5.0	5.0	5.0	5.0
Medium Pressure Steam, Hot Water or other fluid	251-350	3.0	3.0	4.0	4.5	4.5	4.5
Low Pressure Steam, Hot Water or other fluid	201-250	2.5	2.5	2.5	2.5	3.0	3.0
Hot Water or other fluid**	141-200	1.5	1.5	1.5	2.0	2.0	2.0
Hot Water or other fluid**	105-140	1.0	1.0	1.0	1.5	1.5	1.5
<u>Low Temperature Piping</u> Cold Water and Drain Lines, Refrigerant, *** Chilled Water	40-55 <40	0.5 0.5	0.5 0.5	0.5 1.0	1.0 1.0	1.0 1.0	1.0 1.5

* Runouts to individual coils between control valve and coil (not exceeding 4 ft. in length).

** Include refrigerant hot gas.

*** Include refrigerant suction. Liquid line insulation is not required.

**** Increase insulation thickness for exterior piping by .5 inches minimum.

END OF SECTION 23 07 19

SECTION 23 08 00 - HVAC COMMISSIONING

PART 1 - GENERAL

1.1 GENERAL: Furnish labor and material to accomplish complete HVAC commissioning as specified herein. If this Contractor cannot meet the specification herein, the Contractor shall employ the services of an independent commissioning expert.

1.2 PURPOSE

A. Verify operation and functional performance of HVAC systems for compliance with design intent, drawings and specifications.

B. Document HVAC test inspections.

C. Verify application of operation and maintenance manuals, as-built documents, spare parts listing, special tool listing, and other items that support the HVAC systems and equipment.

D. Coordinate and direct training to personnel for operation and maintenance of HVAC systems and equipment.

1.3 QUALITY ASSURANCE: Reference ASHRAE Guideline 1-1996, Guideline for Commissioning of HVAC Systems, and SMACNA HVAC System Commissioning Manual.

1.4 Commissioning Team shall consist of:

A. The contractor's representative

B. The controls sub-contractor's representative

C. The sheet metal sub-contractor's representative

D. The electrical sub-contractor's representative

E. The engineer's representative

F. The equipment vendors representative

G. The testing, adjusting and balancing Contractor's representative

H. The owner's representative

1.5 CONTRACTOR RESPONSIBILITY

A. Plan, organize, and implement the commissioning process as specified herein.

B. Prepare the commissioning plan and ensure its distribution for review and comment.

C. Revise the commissioning plan as required during construction.

D. Chair commissioning meetings and prepare and distribute minutes to all commissioning team members, whether or not they attend the meeting.

E. Coordinate commissioning activities among all contractors, sub-trades, and suppliers.

F. Carry out all required system readiness checks and documents the results as the checks are done.

G. In cooperation with the controls sub-contractor, ensure all control point checkouts are carried out and the results documented as the checks are done.

H. Observe or verify all start-ups and initial system operations tests and checks, which shall encompass all specified functional performance tests, ensuring the results are documents as the tests and checks are done.

I. Ensure equipment and systems are operated for functional performance verification purposes.

J. Ensure all required instruction and demonstrations are provided to the owner's designated operating staff.

1.6 COMMISSIONING PLAN

A. Within one month after award of contract, the contractor shall review the design intent and intended commissioning procedure with the engineer. Within 3 months of award of contract, the contractor shall submit a detailed Commissioning Plan to the engineer for review. The Commissioning Plan shall contain the information necessary to document the commissioning process as it progresses from pre-start-up checks, to start-up, and initial operation and finally to functional performance verification of all systems. The Commissioning Plan must include detailed check lists, relevant to guiding and carrying out. ASHRAE Guideline 1 should be used as outline.

B. Phase 1 – Systems Readiness and Start-up:

Before starting any equipment or systems, complete the system readiness or pre-start checks in the commissioning plan and document the results. The following conditions and items shall be completed as applicable.

1. Piping systems have been pressure tested as specified, found to be tights, with reports submitted.

2. Equipment has been lubricated.
3. Air system cleaning is complete, and particulate filters have been installed.
4. Vibration isolation and seismic restraints have been installed to specification and adjusted.
5. Equipment drives have been aligned.
6. Electrical services have been installed and checked.
7. Control point checkouts have been completed.
8. Safety controls have been installed and operation checked.
9. Major equipment start-up has been carried out by manufacturer's representative and required start-up reports completed, submitted and approved.

All checks shall be documented on the relevant checklists as they are carried out. Deficiencies or incomplete work shall be corrected, and the checks repeated until the installation is ready for operation, before proceeding to Phase 2 of the process.

C. Phase 2 – Initial Operation:

In Phase 2 of the commissioning process, the contractor completes the testing, balancing, and calibration of all components and systems. They also operate all systems through all specified modes of operation, and test system responses to specified abnormal or emergency conditions.

Work carried out during this phase of commissioning shall include the following:

1. Air systems balancing, including positioning of all balance valve.
2. Correction of problems revealed during balancing, including changes to fan speeds or blade pitch as necessary.
3. Setting up and calibrating all automatic temperature control devices, including adjustments to control valves and damper actuators.
4. Verify the balancing contractor, and controls contractor are working together, setting up air flows and controls calibrations for variable volume terminal units and air valves where applicable.
5. Checking operation of all fire dampers, as was done in Phase 1, all checks and tests shall be documented on the relevant checklists as they are carried out.
   Deficiencies or incomplete work shall be corrected, and the checks or test repeated until correct installation and function has been confirmed and the installation is ready for engineer verification.

D. Phase 3 – Functional Performance Verification

All equipment and systems shall be operated through the entire specified sequence of operations, as directed by the engineer for witnessing and verifying acceptable operation.

During this phase of commissioning, the following checks and test may be required by the engineer and shall be allowed for:

1. Checking the location and accessibility of all access panels.
2. Operation of all controls systems devices, both sensors and actuators.
3. Demonstration of acceptable noise and vibration levels from any equipment, under its full range of operational conditions.

4. Operation of equipment and systems under every specified mode of operation and sequence of control.
5. Operation of equipment and systems under normal, abnormal, and emergency conditions.
6. Acceptance testing as indicated in 3.3 herein.

E. Phase 4 – Demonstration and Instruction:

The formal demonstration and instruction for operating staff shall commence once the Phase 3 commissioning is complete and substantial completion achieved.

Demonstration and instruction shall cover all equipment and systems, and their controls. Detailed requirements are listed in the following sections of the specification.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

Instrumentation will be provided by agency performing prior tests. Instruments will be operated by individual agency requested by the HVAC Commissioning Authority, as specified elsewhere herein.

PART 3 - EXECUTION

3.1 HVAC Commissioning shall begin after HVAC equipment and systems, along with related equipment, systems, structures and areas are complete.

3.2 THE FOLLOWING SYSTEMS SHALL BE COMMISSIONED:

A. Hot Water and Chilled Water Piping Systems – pressure tests; expansion tanks; flow balancing verification.

B. Duct Systems – Installation checks; flow balancing verification; leak testing.

C. Refrigerant Systems and Chillers – Installation checks; checkout and start-up by manufacturer's representative; performance measurements, including capacity, evaporator and condenser flows, motor amperage, and controls operation (e.g., staging and capacity modulation). Leak testing, dehydration charging.

D. Pumps – Checks on alignment, rotation, motor current draw, flows, and pressures.

E. Air-Handling Units – Installation checks; capacity tests for heating, cooling, air flow, and static pressures; operation of all controls.

F. Air Terminal Devices – Installation checks; for constant and variable air volume (CAV) (VAV) units, flow adjustments and calibration coordinated with controls and air balancing; controls operation, including flow modulation, reheat, controls responses.

G. Controls and EMCS – Installation and operation of all devices; complete operation of all controls sequences in coordination with commissioning of all controlled systems.

H. Heating System and Boilers – Installation checks; checkout and start-up by manufacturer's representative; performance measurements, including capacity and flow rate. Verify control operation. (i.e., staging and modulation).

3.3 ACCEPTANCE TESTING

A. An acceptance test of the HVAC system shall be performed by the Contractor in the presence of the Owner's representative and the Local Fire Marshal. Upon completion of the successful test, the Contractor shall so certify in writing to the Owner and General Contractor.

B. The Contractor shall also utilize all sub-contractors such as sheetmetal, balancing, piping, controls and commissioning agent, and other contractors such as electrical, plumbing, fire alarm and communications as required to perform this acceptance test.

C. The acceptance test shall be performed to determine that the protective measures required as outlined in NFPA 90A and shall function when needed in order to restrict the spread of fire and smoke.

D. The acceptance test shall include testing the HVAC system to determine its full functionability and in compliance with NFPA 90A and the sequence of operation. All controls and equipment shall be modulated throughout their entire ranges and adjustments shall be made for optimum performance.

1. Portions of control or alarm systems are permitted to have standby power or other emergency modes of operation.
2. The tests shall be performed to determine that the system operates under the standby power or emergency operation mode as well as under normal conditions.

E. All fire, smoke, combination fire/smoke dampers and ceiling dampers shall be operated and tested by Contractor prior to occupancy of a building to determine that they function in accordance with NFPA 90A, compliance report must be forwarded to Engineer and Owner.

END OF SECTION 23 08 00

SECTION 23 09 23 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 23 09 13.23 - Sensors and Transmitters

1. Hydronic temp sensor wells and sockets

B. Section 23 09 13.33 - Control Valves

1. Control valves

1.2 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. None

1.3 PRODUCTS NOT FURNISHED OR INSTALLED UNDER BUT INTEGRATED WITH THE WORK OF THIS SECTION

A. None

1.4 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The following sections constitute related work:

1. Section 23 05 00 - Common Work Results for HVAC
2. Section 23 05 66 – Anti Microbial Ultraviolet Emitters for HVAC
3. Section 23 21 16 - HVAC Piping
4. Section 23 21 23 – HVAC Pumps
5. Section 23 31 13 – Ductwork
6. Section 23 33 10 – Ductwork Accessories
7. Section 23 34 23 – HVAC Power Ventilators
8. Section 23 36 00 – Air Terminal Units
9. Section 23 40 00 - HVAC Air Cleaning Devices
10. Section 23 57 00 – Heat Exchangers
11. Section 23 74 00 – Packaged Rooftop Units
12. Section 23 81 26 – Ductless Split Systems
13. Section 23 82 00 – Hydronic Terminal Heating Units

1.5 DESCRIPTION

A. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and a web-based operator interface.

B. System software shall be based on a server/thin client architecture, designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the owner's local area network, and (at the owner's discretion) over the Internet. The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to download programming into the controllers.

C. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. I/O points, schedules, setpoints, trends and alarms specified in 23 09 93 – "Sequence of Operations for HVAC Controls" shall be BACnet objects.

D. All new HVAC equipment and systems shall be provided with new DDC controls and be an extension of the existing Automated Logic system (ALC).

E. Existing HVAC equipment in the Middle School which are currently not on the ALC system shall be converted under this project. See Appendix C.

1.6 APPROVED CONTROL SYSTEM MANUFACTURERS

A. The following are approved control system suppliers, manufacturers, and product lines:

Supplier	Manufacturer	Product Line
Any	Automated Logic Corporation	WebCTRL

The above list does not indicate order of preference. Inclusion on this list does not guarantee acceptance of products or installation. Control systems shall comply with the terms of this specification.

1. The Contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line unless Owner approves use of multiple manufacturers.

2. Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

1.7 QUALITY ASSURANCE

A. Installer and Manufacturer Qualifications

1. Installer shall have an established working relationship with Control System Manufacturer.

2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

1.8 CODES AND STANDARDS

A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:

1. National Electric Code (NEC)
2. International Building Code (IBC)

   a. Section 719 Ducts and Air Transfer Openings
   b. Section 907 Fire Alarm and Detection Systems
   c. Section 909 Smoke Control Systems
   d. Chapter 28 Mechanical

3. International Mechanical Code (IMC)
4. ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Systems

1.9 SYSTEM PERFORMANCE

A. Performance Standards: System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Graphic Display: A graphic with 20 dynamic points shall display with current data within 10 sec.

2. Graphic Refresh: A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.

3. Configuration and Tuning Screens: Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.

4. Object Command: Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.

5. Alarm Response Time: An object that goes into alarm shall be annunciated at the workstation within 45 sec.

6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.

7. Performance: Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.

8. Multiple Alarm Annunciation: Each workstation on the network shall receive alarms within 5 sec of other workstations.

9. Reporting Accuracy: System shall report values with minimum end-to-end accuracy listed in Table 1.

10. Control Stability and Accuracy: Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table-1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5ºC (±1ºF)
Ducted Air	±0.5ºC (±1ºF)
Outside Air	±1.0ºC (±2ºF)
Dew Point	±1.5ºC (±3ºF)
Water Temperature	±0.5ºC (±1ºF)
Delta-T	±0.15º (±0.25ºF)
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO2)	±50 ppm

Note 1: Accuracy applies to 10%–100% of scale
Note 2: For both absolute and differential pressure
Note 3: Not including utility-supplied meters

Table 2
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0–1.5 kPa (0–6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0ºC (±2.0ºF)	
Duct Temperature	±1.5ºC (±3ºF)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	MPa (1–150 psi) 0–12.5 kPa (0–50 in. w.g.) differential

1.10 SUBMITTALS

A. Product Data and Shop Drawings: The contractor shall provide shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD compatible files on magnetic or optical disk (file format: .DWG, .DXF, .VSD, or comparable) and three 11” x 17” prints of each drawing. When manufacturer’s cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall be provided within 12 weeks of contract award. Submittals shall include:

1. DDC System Hardware

   a. A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
   b. Manufacturer’s description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:

      1) Direct digital controllers (controller panels)
      2) Transducers and transmitters
      3) Sensors (including accuracy data)
      4) Actuators
      5) Valves
      6) Relays and switches
      7) Control panels
      8) Power supplies
      9) Batteries
      10) Operator interface equipment
      11) Wiring

   c. Wiring diagrams and layouts for each control panel: Show termination numbers.
   d. Schematic diagrams for all field sensors and controllers: Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.

2. Central System Hardware and Software

   a. A complete bill of material of equipment used indicating quantity, manufacturer, model number, and relevant technical.
   b. Manufacturer’s description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:

      1) Central Processing Unit (CPU) or web server

2) Monitors
3) Keyboards
4) Power supplies
5) Battery backups
6) Interface equipment between CPU or server and control panels
7) Operating System software
8) Operator interface software
9) Color graphic software
10) Third-party software

c. Schematic diagrams for all control, communication, and power wiring: Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show interface wiring to control system.
d. Network riser diagrams of wiring between central control unit and control panels.

3. Controlled Systems

a. Riser diagrams showing control network layout, communication protocol, and wire types.
b. A schematic diagram of each controlled system: The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.
c. A schematic wiring diagram of each controlled system: Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
d. An instrumentation list (Bill of Materials) for each controlled system: List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
e. A mounting, wiring, and routing plan-view drawing. The design shall take into account HVAC, electrical, and other systems' design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.
f. A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.
g. A point list for each control system: List I/O points and software points specified in Section 23 09 93. Indicate alarmed and trended points.

4. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.
5. A description of the proposed process along with all report formats and checklists to be used in Section 23 09 23 Article3.17 (Control System Demonstration and Acceptance).
6. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.

B. Schedules

1. Within one month of contract award, provide a schedule of the work indicating the following:

a. Intended sequence of work items

b. Start date of each work item
c. Duration of each work item
d. Planned delivery dates for ordered material and equipment and expected lead times
e. Milestones indicating possible restraints on work by other trades or situations

2. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.

C. Project Record Documents: Upon completion of installation, submit three copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and shall include:

1. Project Record Drawings: As-built versions of submittal shop drawings provided as AutoCAD compatible files on magnetic or optical media (file format: .DWG, .DXF, .VSD, or comparable) and as 11" x 17" prints.
2. Testing and Commissioning Reports and Checklists: Completed versions of reports, checklists, and trend logs used to meet requirements of Section 23 09 23 Article3.17 (Control System Demonstration and Acceptance).
3. Operation and Maintenance (O&M) Manual.
4. As-built versions of submittal product data.
5. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
6. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
7. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
8. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
9. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
10. Graphic files, programs, and database on magnetic or optical media.
11. List of recommended spare parts with part numbers and suppliers.
12. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
13. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
14. Licenses, guarantees, and warranty documents for equipment and systems.
15. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

D. Training Materials: Provide course outline and materials for each class at least six weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary to meet Owner's needs. Engineer will review and approve course outlines and materials at least three weeks before first class.

1.11 WARRANTY

A. Warrant work as follows:

1. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.
2. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
3. If the engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, the engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
4. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve the contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
5. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

1.12 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

1. Graphics
2. Record drawings
3. Database
4. Application programming code
5. Documentation

1.13 DEFINITIONS

Term	**Definition**
BACnet Interoperability Building Blocks (BIBB)	**A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specification.**
BACnet/BACnet Standard	**BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.**
Control Systems Server	**A computer(s) that maintain(s) the systems configuration and programming database.**

Term	**Definition**
Controller	**Intelligent stand-alone control device. Controller is a generic reference to building controllers, custom application controllers, and application specific controllers.**
Direct Digital Control	**Microprocessor-based control including Analog/Digital conversion and program logic.**
Gateway	**Bi-directional protocol translator connecting control systems that use different communication protocols.**
Local Area Network	**Computer or control system communications network limited to local building or campus.**
Master-Slave/Token Passing	**Data link protocol as defined by the BACnet standard.**
Point-to-Point	**Serial communication as defined in the BACnet standard.**
Primary Controlling LAN	**High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.**
Protocol Implementation Conformance Statement	**A written document that identifies the particular options specified by BACnet that are implemented in a device.**
Router	**A device that connects two or more networks at the network layer.**
Wiring	**Raceway, fittings, wire, boxes and related items.**

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.

B. Install new wiring and network devices as required to provide a complete and workable control network.

C. Use existing Ethernet backbone for network segments marked "existing" on project drawings.

D. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

E. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in Section 23 09 93. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

F. Workstations, Building Control Panels, and Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight saving and standard time as applicable.

G. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

2.3 OPERATOR INTERFACE

A. Operator Interface: Web server shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information. The Operator Workstation or server shall conform to the BACnet Operator Workstation (B-OWS) or BACnet Advanced Workstation (B-AWS) device profile as specified in ASHRAE/ANSI 135 BACnet Annex L.

B. Communication: Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135, BACnet Annex J.

C. Hardware:

1. Workstation or web server. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified elsewhere in this document. The following hardware requirements also apply:

    a. The hard disk shall have sufficient memory to store:

        1) All required operator workstation software.
        2) A DDC database at least twice the size of the delivered system database.
        3) One year of trend data based on the points specified to be trended at their specified trend intervals.

    b. Provide additional hardware (communication ports, video drivers, network interface cards, cabling, etc.) to facilitate all control functions and software requirements specified for the DDC system.
    c. Minimum hardware configuration shall include the following:

        1) Quad Core Processor

2) 8 GB RAM
3) 1 TB hard disk providing data at 3.0 Gb/sec
4) 16x DVD+/-RW drive
5) Serial, parallel, and network communication ports and cables as required for proper DDC system operation

D. System Software:

1. Operating System: Web server or workstation shall have an industry-standard professional-grade operating system. Operating system shall meet or exceed the DDC System manufacturers minimum requirements for their software. Acceptable systems include Microsoft Windows 7 or 8, Microsoft Vista, Windows Server 2008 or 2012, Red Hat Enterprise Linux, or Ubuntu Desktop 12.04.

2. System Graphics: The operator interface software shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.

a. Functionality: Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
b. Animation: Graphics shall be able to animate by displaying different image files for changed object status.
c. Alarm Indication: Indicate areas or equipment in an alarm condition using color or other visual indicator.
d. Format: Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in or shall only require widely available no-cost plug-ins (such as Adobe Flash).

3. Custom Graphics: Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in the same formats as are used for system graphics.
4. Graphics Library: Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.

E. System Applications: System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.

1. Automatic System Database Configuration: Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
2. Manual Controller Memory Download: Operators shall be able to download memory from the system database to each controller.
3. System Configuration: The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection. Operators shall be able to configure the system.
4. On-Line Help: Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
5. Security: Each operator shall be required to log on to the system with user name and password in order to view, edit, add, or delete data.

   a. Operator Access: The user name and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users. System Administrators shall also be able to vary and deny each operator's privileges based on the geographic location of the equipment, such as the ability to edit operating parameters in Building A, to view but not edit parameters in Building B, and to not even see equipment in Building C.
   b. Automatic Log Out: Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time shall be user adjustable.
   c. Encrypted Security Data: Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

6. System Diagnostics: The system shall automatically monitor the operation of all building management panels and controllers. The failure of any device shall be annunciated to the operator.
7. Alarm Processing: System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Section 23 09 93 (Sequences of Operation). Alarms shall be BACnet alarm objects and shall use BACnet alarm services.
8. Alarm Messages: Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying on acronyms or mnemonics.
9. Alarm Reactions: Operator shall be able to configure (by object) what, if any actions are to be taken during an alarm. As a minimum, the workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.
10. Alarm and Event log: Operators shall be able to view all system alarms and changes of state from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and delete alarms, and archive closed alarms to the workstation or web server hard disk.
11. Trend Logs: The operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data

and shall be able to archive data to the hard disk. Configure trends as specified in Section 23 09 93 (Sequences of Operation). Trends shall be BACnet trend objects.

12. Object and Property Status and Control: Provide a method for the operator to view, and edit if applicable, the status of any object or property in the system. The status shall be available by menu, on graphics, or through custom programs.
13. Reports and Logs: Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Standard Reports: Furnish the following standard system reports:

    a. Objects: System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
    b. Alarm Summary: Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
    c. Logs: System shall log the following to a database or text file and shall retain data for an adjustable period:

        1) Alarm History:
        2) Trend Data: Operator shall be able to select trends to be logged.
        3) Operator Activity: At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

15. Environmental Index: System shall monitor all occupied zones and compile an index that provides a numerical indication of the environmental comfort within the zone. As a minimum, this indication shall be based upon the deviation of the zone temperature from the heating or cooling setpoint. If humidity is being measured within the zone then the environmental index shall be adjusted to reflect a lower comfort level for high or low humidity levels. Similarly, if carbon dioxide levels are being measured as an indication of ventilation effectiveness then the environmental index shall be adjusted to indicate degraded comfort at high carbon dioxide levels. Other adjustments may be made to the environmental index based upon additional measurements. The system shall maintain a trend of the environmental index for each zone in the trend log. The system shall also compute an average comfort index for every building included in this contract and maintain trendlogs of these building environmental indices. Similarly, the system shall compute the percentage of occupied time that comfortable conditions were maintained within the zones. Through the UI the user shall be able to add a weighting factor to adjust the contribution of each zone to the average index based upon the floor area of the zone, importance of the zone, or other static criteria.
16. Time Span Graphic Replay: Operator shall be able to “replay” any graphic in the system to see how key values changed over an operator-selected period of time. Operator shall be able to select the starting date/time for this display and the end date/time or the display period. On completion of the project specified herein, the BAS contractor shall demonstrate that up to 24 hours of data within the last 30 days of operation cab be instantly replayed. System shall then display the graphic as it would have looked at the beginning of that period, displaying key data, dynamic colors, etc. based upon values recorded at the start time. When the operator starts the replay the graphics and key values shall dynamically change to produce the effect of “fast forwarding” through the designated period of time. Once the system has been operational for at least 30 days, the contractor shall demonstrate that up to 24 hours of data from within the last 30 days can be

replayed on any graphic page. Owner's representative shall choose the graphic pages for this demonstration at the time of the demonstration.

F. Workstation Application Editors: Each PC or browser workstation shall support editing of all system applications. The applications shall be downloaded and executed at one or more of the controller panels.

1. Controller: Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.
2. Scheduling: An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and schedule type. Exception schedules and holidays shall be shown clearly on the calendar. The start and stop times for each object shall be adjustable from this interface.
3. Custom Application Programming: Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

a. Language: Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
b. Programming Environment: Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.

c. Independent Program Modules: Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
d. Debugging and Simulation: Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.
e. Conditional Statements: Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
f. Mathematical Functions: Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.
g. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.

1) Time Variables: Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.
2) System Variables: Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

G. Portable Operator's Terminal: Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

2.4 CONTROLLER SOFTWARE

A. Furnish the following applications for building and energy management: All software application shall reside and operate in the system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

B. System Security: See Paragraph 2.3.E.5 (Security) and Paragraph 2.3.E.14.c.iii (Operator Activity).

C. Scheduling: Provide the capability to execute control functions according to a user created or edited schedule. Each schedule shall provide the following schedule options as a minimum:

1. Weekly Schedule: Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
2. 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 has executed, the system shall discard and replace the exception schedule with the standard schedule for that day of the week.
3. Holiday Schedules: Provide the capability for the operator to define up to 24 special or holiday schedules. These schedules will be repeated each year. The operator shall be able to define the length of each holiday period.

D. System Coordination: Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

E. Binary Alarms: Each binary object shall have the capability to be configured to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

F. Analog Alarms: Each analog object shall have both high and low alarm limits. The operator shall be able to enable or disable these alarms.

G. Alarm Reporting: The operator shall be able to determine the action to be taken in the event of an alarm. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display on graphics.

H. Remote Communication: System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.

I. Demand Limiting:

1. The demand-limiting program shall monitor building power consumption from a building power meter (provided by others) which generates pulse signals or a BACnet communications interface. An acceptable alternative is for the system to monitor a watt transducer or current transformer attached to the building feeder lines.

2. When power consumption exceeds adjustable levels, system shall automatically adjust setpoints, de-energize low-priority equipment, and take other programmatic actions to reduce demand as specified in Section 23 09 93 (Sequences of Operation). When demand drops below adjustable levels, system shall restore loads as specified.

J. Maintenance Management: The system shall be capable of generating maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in 23 09 93 (Sequences of Operation).

K. Sequencing: Application software shall sequence chillers, boilers, and pumps as specified in Section 23 09 93 (Sequences of Operation).

L. PID Control: System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or tostage a series of outputs. The calculation interval, PID gains, and other tuning parameters shall be adjustable by a user with the correct security level.

M. Staggered Start: System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

N. Energy Calculations:

1. The system shall accumulate and convert instantaneous power (kW) or flow rates (L/s [gpm]) to energy usage data.
2. The system shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.

O. Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

P. On and Off Control with Differential: Provide an algorithm that allows a binary output to be cycled based on a controlled variable and a setpoint. The algorithm shall be direct-acting or reverse-acting.

Q. Runtime Totalization: Provide software to totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified in Section 23 09 93 (Sequence of Operations).

2.5 CONTROLLERS

A. General: Provide an adequate number of Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified in Section 23 09 23 Article 1.9 (System Performance). Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.

B. BACnet:

1. Building Controllers (BCs): Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L, and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
2. Advanced Application Controllers (AACs): Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
3. Application Specific Controllers (ASCs): Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
4. Smart Sensors (SSs): Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.
5. BACnet Communication:

   a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
   b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
   c. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
   d. Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

   e. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
   f. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.

C. Communication:

1. Service Port: Each controller shall provide a service communication port for connection to a Portable Operator’s Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
2. Signal Management: BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
3. Data Sharing: Each BC and AAC shall share data as required with each networked BC and AAC.
4. Stand-Alone Operation: Each piece of equipment specified in Section 23 09 93 shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.

D. Environment: Controller hardware shall be suitable for anticipated ambient conditions.

1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -20°F to 140°F.
2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 32°F to 120°F.

E. Keypad: Provide a local keypad and display for each BC and AAC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use. If the manufacturer does not normally provide a keypad and display for each BC and AAC, provide the software and any interface cabling needed to use a laptop computer as a Portable Operator’s Terminal for the system.

F. Real-Time Clock: Controllers that perform scheduling shall have a real-time clock.

G. Serviceability: Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

H. Memory:

1. Controller memory shall support operating system, database, and programming requirements.
2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

I. Immunity to Power and Noise: Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.

J. Transformer: ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.6 INPUT AND OUTPUT INTERFACE

A. General: Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Protection: All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no controller damage.

C. Binary Inputs: Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

D. Pulse Accumulation Inputs: Pulse accumulation inputs shall conform to binary input requirements and shall also accumulate up to 10 pulses per second.

E. Analog Inputs: Analog inputs shall allow the monitoring of low-voltage (0–10 Vdc), current (4–20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

F. Binary Outputs: Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on Building Controllers shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

G. Analog Outputs: Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0–10 Vdc or a 4–20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

H. Tri-State Outputs: Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

I. Universal Inputs and Outputs: Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

J. System Object Capacity: The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system

2.7 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies: Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

a. Unit shall operate between 32°F and 120°F. EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
b. Line voltage units shall be UL recognized and CSA listed.

B. Power Line Filtering:

1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:

a. Dielectric strength of 1000 V minimum
b. Response time of 10 nanoseconds or less
c. Transverse mode noise attenuation of 65 dB or greater
d. Common mode noise attenuation of 150 dB or greater at 40–100 Hz

2.8 AUXILIARY CONTROL DEVICES

A. Motorized Control Dampers, unless otherwise specified elsewhere, shall be as follow:

1. Type: Control dampers shall be the parallel or opposed-blade type as specified below or as scheduled on drawings.

a. Outdoor and return air mixing dampers and face-and-bypass dampers shall be parallel-blade and shall direct airstreams toward each other.
b. Other modulating dampers shall be opposed-blade.
c. Two-position shutoff dampers shall be parallel- or opposed-blade with blade and side seals.

2. Frame: Damper frames shall be 13 gauge galvanized steel channel or ⅛ in. extruded aluminum with reinforced corner bracing.
3. Blades: Damper blades shall not exceed 8 in. in width or 48 in. in length. Blades shall be suitable for medium velocity (10 m/s [2000 fpm]) performance. Blades shall be not less than 16 gauge.
4. Shaft Bearings: Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.
5. Seals: Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than 50 $L/s \cdot m^2$ (10 cfm per ft^2) at 1000 Pa (4 in. w.g.) differential pressure. Blades shall be airfoil type suitable for wide-open face velocity of 7.5 m/s (1500 fpm).
6. Sections: Individual damper sections shall not exceed 48 in. × 60 in. Each section shall have at least one damper actuator.
7. Modulating dampers shall provide a linear flow characteristic where possible.
8. Linkages: Dampers shall have exposed linkages.

B. Electric Damper and Valve Actuators:

1. Stall Protection: Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.
2. Spring-return Mechanism: Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).

3. Signal and Range: Proportional actuators shall accept a 0–10 Vdc or a 0–20 mA control signal and shall have a 2–10 Vdc or 4–20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in paragraph 2.6H.)
4. Wiring: 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.
5. Manual Positioning: Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.

C. Control Valves:

1. Control valves shall be two-way or three-way type for two-position or modulating service as shown.
2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

    a. Water Valves:

        1) Two-way: 150% of total system (pump) head.
        2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

    b. Steam Valves: 150% of operating (inlet) pressure.

3. Water Valves:

    a. Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.

    b. Sizing Criteria:

        1) Two-position service: Line size.
        2) Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.
        3) Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 35 kPa (5 psi) maximum.
        4) Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.
        5) Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.

    c. Water valves shall fail normally open or closed, as scheduled on plans, or as follows:

        1) Water zone valves—normally open preferred.
        2) Heating coils in air handlers—normally open.
        3) Chilled water control valves—normally closed.

4) Other applications—as scheduled or as required by sequences of operation.

4. Steam Valves:

a. Body and trim materials shall be in accordance with manufacturer's recommendations for design conditions and service with linear ports for modulating service.
b. Sizing Criteria:

1) Two-position service: pressure drop 10% to 20% of inlet psig.
2) Modulating service: 100 kPa (15 psig) or less; pressure drop 80% of inlet psig.
3) Modulating service: 101 to 350 kPa (16 to 50 psig); pressure drop 50% of inlet psig.
4) Modulating service: over 350 kPa (50 psig); pressure drop as scheduled on plans.

D. Binary Temperature Devices:

1. Low-Voltage Space Thermostats: Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 55°F–85°F setpoint range, 2°F maximum differential, and vented ABS plastic cover.
2. Line-Voltage Space Thermostats: Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 55°F–85°F setpoint range, 2°F maximum differential, and vented ABS plastic cover.
3. Low-Limit Thermostats: Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 20 ft long. Element shall sense temperature in each 1 ft section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

E. Temperature Sensors:

1. Type: Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.
2. Duct Sensors: Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 5 ft in length per 10 ft^2 of duct cross-section.
3. Immersion Sensors: Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.
4. Space Sensors: Space sensors shall have setpoint adjustment, override switch, display, and communication port as shown.
5. Differential Sensors: Provide matched sensors for differential temperature measurement.

F. Humidity Sensors:

1. Duct and room sensors shall have a sensing range of 20%–80%.
2. Duct sensors shall have a sampling chamber.
3. Outdoor air humidity sensors shall have a sensing range of 20%–95% RH and shall be suitable for ambient conditions of -40°F–170°F.
4. Humidity sensors shall not drift more than 1% of full scale annually.

G. Flow Switches: Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).

1. Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
2. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

H. Relays:

1. Control Relays: Control relays shall be plug-in type, UL listed, and shall have dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Time Delay Relays: Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

I. Override Timers:

1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0–6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

J. Current Transmitters:

1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4–20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
3. Unit shall be split-core type for clamp-on installation on existing wiring.

K. Current Transformers:

1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.
3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

L. Voltage Transmitters:

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4–20 mA output with zero and span adjustment.

2. Adjustable full-scale unit ranges shall be 100–130 Vac, 200–250 Vac, 250–330 Vac, and 400–600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

M. Voltage Transformers:

1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 4°C–55°C (40°F–130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

N. Power Monitors:

1. Selectable rate pulse output for kWh reading, 4–20 mA output for kW reading, N.O. alarm contact, and ability to operate with 5.0 amp current inputs or 0–0.33 volt inputs.
2. 1.0% full-scale true RMS power accuracy, +0.5 Hz, voltage input range 120–600 V, and auto range select.
3. Under voltage/phase monitor circuitry.
4. NEMA 1 enclosure.
5. Current transformers having a 0.5% FS accuracy, 600 VAC isolation voltage with 0–0.33 V output. If 0–5 A current transformers are provided, a three-phase disconnect/shorting switch assembly is required.

O. Hydronic Flowmeters:

1. Insertion-Type Turbine Meter:

   a. Dual counter-rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Single turbine for piping 2 inches and smaller. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag.
   b. Insertion type complete with 'hot-tap' isolation valves to enable sensor removal without water supply system shutdown.
   c. Sensing method shall be impedance sensing (non-magnetic and non-photoelectric)
   d. Volumetric accuracy:

      1) ± 0.5% of reading at calibrated velocity
      2) ± 1% of reading from 3 to 30 ft/s (10:1 range)
      3) ± 2% of reading from 0.4 to 20 ft/s (50:1 range)

   e. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).
   f. Maximum operating pressure of 400 psi and maximum operating temperature of 200°F continuous (220°F peak).
   g. All wetted metal parts shall be constructed of 316 stainless steel.

h. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearly of 0.1% of span, voltage output of 0-10 Vdc, and current output of 4-20 mA.

2. Magnetic Flow-Tube Type Flowmeter:

a. Sensor shall be a magnetic flowmeter, which utilizes Faraday's Law to measure volumetric fluid flow through a pipe. The flowmeter shall consist of two elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
b. Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).
c. Four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used provided accuracy is as specified.
d. Flow Tube:

1) ANSI class 150 psig steel
2) ANSI flanges
3) Protected with PTFE, PFA, or ETFE liner rated for 245°F minimum fluid temperature

e. Electrode and grounding material:

1) 316L Stainless steel or Hastelloy C
2) Electrodes shall be fused to ceramic liner and not require o-rings.

f. Electrical Enclosure: NEMA 4, 7
g. Approvals:

1) UL or CSA
2) NSF Drinking Water approval for domestic water applications.

h. Performance:

1) Accuracy shall be ±0.5% of actual reading from 3 to 30 ft/s flow velocities, and 0.015 ft/s from 0.04 to 3 ft/s.
2) Stability: 0.1% of rate over six months.
3) Meter repeatability shall be ±0.1% of rate at velocities > 3 ft/s.

3. Magnetic Insertion-Type Flowmeter:

a. Magnetic Faraday point velocity measuring device.
b. Insertion type complete with hot-tap isolation valves to enable sensor removal without water supply system shutdown.
c. 4-20 mA transmitter proportional to flow or velocity.
d. Accuracy: larger of 1% of reading and 0.2 ft/s.
e. Flow range: 0.2 to 20 ft/s, bi-directional.

f. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).

4. Vortex Shedding Flowmeter:

a. Output: 4-20 mA, 0-10 Vdc, 0-5 Vdc.
b. Maximum Fluid Temperature: 800ºF (427 °C).
c. Wetted Parts: Stainless Steel.
d. Housing: NEMA 4X.
e. Turndown: 25:1 minimum.
f. Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for steam and gases.
g. Body: Wafer style or ANSI flanged to match piping specification.

5. Transit-Time Ultrasonic Flowmeter

a. Clamp-On transit-time ultrasonic flowmeter
b. Wide-Beam transducer technology
c. 4-20 mA transmitter proportional to flow or velocity.
d. Accuracy: 0.5% of reading in range 1 to 30 ft/s, 0.001 ft/s sensitivity.

P. Thermal Energy Meters:

1. Matched RTD, solid state, or thermistor temperature sensors with a differential temperature accuracy of ±0.15°F.
2. Flow meter: See "Hydronic Flowmeters" section.
3. Unit accuracy of ±1% factory calibrated, traceable to NIST with certification.
4. NEMA 1 enclosure.
5. Panel mounted display.
6. UL listed.
7. Isolated 4–20 ma signals for energy rate and supply and return temperatures and flow.

Q. Current Switches:

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

R. Pressure Transducers:

1. Transducers shall have linear output signal and field-adjustable zero and span.
2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
3. Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4–20 mA output, suitable mounting provisions, and block and bleed valves.
4. Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300psi.)Transducer shall have 4–20 mA output, suitable mounting provisions, and 5-valve manifold.

S. Differential Pressure Switches: Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

T. Pressure-Electric (PE) Switches:

1. Shall be metal or neoprene diaphragm actuated, operating pressure rated for 0–175 kPa (0–25 psig), with calibrated scale minimum setpoint range of 14–125 kPa (2–18 psig) minimum, UL listed.
2. Provide one- or two-stage switch action (SPDT, DPST, or DPDT) as required by application. Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.
3. Switches shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
4. Each pneumatic signal line to PE switches shall have permanent indicating gauge.

U. Occupancy Sensors: Occupancy sensors shall utilize Passive Infrared (PIR) and/or Microphonic Passive technology to detect the presence of people within a room. Sensors shall be mounted as indicated on the approved drawings. The sensor output shall be accessible by any lighting and/or HVAC controller in the system. Occupancy sensors shall be capable of being powered from the lighting or HVAC control panel, as shown on the drawings. Occupancy sensor delay shall be software adjustable through the user interface and shall not require manual adjustment at the sensor.

V. Local Control Panels:

1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.
2. Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

2.9 WIRING AND RACEWAYS

A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.

B. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

2.10 FIBER OPTIC CABLE SYSTEM

A. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.

B. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

PART 3 - EXECUTION

3.1 EXAMINATION

A. 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.

B. 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. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by—and at the expense of—this contractor.

3.2 PROTECTION

A. The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.

B. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 COORDINATION

A. Site:

1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Submittals: See Section 23 09 23 Article 1.10 (Submittals).

C. Test and Balance:

1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
2. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
3. In addition, the contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.

D. Life Safety:

1. Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as specified in Section 23 09 93 (Sequences of Operation).
2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as specified in Section 23 09 93 (Sequences of Operation).
3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.

E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

1. All communication media and equipment shall be provided as specified in Section 23 09 23 Article 2.2 (Communication).
2. Each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the sequences of operation described in Section 23 09 93.
3. The contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
4. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
5. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.4 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install equipment in readily accessible locations as defined by Chapter 1 Article 100 Part A of the National Electrical Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.5 FIELD QUALITY CONTROL

A. All work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances as identified in Section 23 09 23 Article 1.8 (Codes and Standards).

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

C. Contractor shall have work inspection by local and/or state authorities having jurisdiction over the work.

3.6 EXISTING EQUIPMENT

A. Wiring: The contractor may reuse any abandoned wires. The integrity of the wire and its proper application to the installation are the responsibility of the contractor. The wire shall be properly identified and tested in accordance with this specification. Unused or redundant wiring must be properly identified as such.

B. Local Control Panels: The contractor may reuse any existing local control panel to locate new equipment. All redundant equipment within these panels must be removed. Panel face cover must be patched to fill all holes caused by removal of unused equipment or replaced with new.

C. Repair: Unless otherwise directed, the contractor is not responsible for repair or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the engineer is to be notified immediately.

D. Temperature Sensor Wells: The contractor may reuse any existing wells in piping for temperature sensors. These wells shall be modified as required for proper fit of new sensors.

E. Indicator Gauges: Where these devices remain and are not removed, they must be made operational and recalibrated to ensure reasonable accuracy.

F. Room Thermostats: Room thermostats may be reused. Remove and deliver unnecessary thermostats to Owner unless otherwise noted. Patch and finish holes and marks left by removal to match existing walls.

G. Electronic Sensors and Transmitters: Unless specifically noted otherwise, existing sensors and transmitters may be reused. Remove and deliver unnecessary sensors and transmitters to Owner.

H. Controllers and Auxiliary Electronic Devices: Existing controllers and auxiliary electronic devices may be reused unless specifically noted otherwise. Recondition as necessary. Remove unnecessary sensors and transmitters.

I. Damper Actuators, Linkages, and Appurtenances: Existing damper actuators, linkages, and appurtenances may be reused unless specifically noted otherwise. Recondition as necessary. Remove and deliver unnecessary equipment to Owner.

J. Control Valves: Existing control valves may be reused unless specifically noted otherwise. Recondition as necessary.

K. Control Compressed Air Systems: Existing control compressed air systems may be reused unless specifically noted otherwise. Recondition as necessary.

L. Existing System Operating Schedule: The mechanical system must remain in operation and shall maintain space comfort at all times between the hours of6 a.m. and 9 p.m., Monday through Friday. No modifications to the system shall cause mechanical system to be shut down for more than 15 minutes or to fail to maintain space comfort conditions during any such period. Perform cut-over of controls that cannot meet these conditions outside of operational hours.

M. The scheduling of fans through existing or temporary time clocks or control system shall be maintained throughout the DDC system installation

N. Install control panels where shown.

O. Modify existing starter control circuits, if necessary, to provide hand-off-auto control of each controlled starter. If new starters or starter control packages are required, these shall be included as part of this contract.

P. Patch holes and finish to match existing walls.

3.7 WIRING

A. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification. Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.

B. All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.

C. All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet Class 2 current limit.

D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for the intended application.

E. All wiring in mechanical, electrical, or service rooms – or where subject to mechanical damage – shall be installed in raceway at levels below 10ft.

F. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

G. Do not install wiring in raceway containing tubing.

H. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 10 ft intervals.

I. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

J. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

K. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

L. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

M. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

N. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

O. Size of raceway and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer’s recommendations and NEC requirements, except as noted elsewhere.

P. Include one pull string in each raceway 1 in. or larger.

Q. Use color-coded conductors throughout with conductors of different colors.

R. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

S. Conceal all raceways except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 in. from high-temperature equipment (e.g. steam pipes or flues).

T. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

U. Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.

V. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.

W. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

X. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 3 ft in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

Y. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.8 COMMUNICATION WIRING

A. The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling

C. Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.

D. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.

F. 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 manufacturer’s instructions.

G. All runs of communication wiring shall be unspliced length when that length is commercially available.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

J. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:

1. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 30 pF per foot.

2. The maximum length of an MS/TP segment is 4000 ft with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
4. An MS/TP EIA-485 network shall have no T connections.

3.9 FIBER OPTIC CABLE

A. 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.

B. 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.

3.10 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by wall framing.

D. All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.

E. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1 ft of sensing element for each 1 ft^2 of coil area.

G. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 10 ft downstream.

H. All pipe-mounted temperature sensors shall be installed in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

I. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

J. Differential Air Static Pressure:

1. Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static

pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.

2. Return Duct Static Pressure: Pipe high-pressure tap to duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.

3. Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.

4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.

5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.

6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shut-off valves installed before the tee.

K. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

L. Install humidity sensors for duct mounted humidifiers at least 10 ft downstream of the humidifier. Do not install filters between the humidifier and the sensor.

3.11 FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Adjust flow switch according to manufacturer's instructions.

3.12 ACTUATORS

A. General: Mount and link control damper actuators according to manufacturer's instructions.

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
3. Provide all mounting hardware and linkages for actuator installation.

B. Electric/Electronic:

1. Dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. Actuators shall be mounted following manufacturer's recommendations.
2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

C. Pneumatic Actuators:

1. Size pneumatic damper actuator to operate the related control damper(s) with sufficient reserve power to provide smooth modulating action or two-position action. Actuator also shall be sized for proper speed of response at the velocity and pressure conditions to which the control damper is subject.
2. Pneumatic damper actuators shall produce sufficient torque to close off against the maximum system pressures encountered. Size the pneumatic damper actuator to close off against the fan shutoff pressure, as a minimum.
3. Where two or more pneumatic damper actuators are installed for interrelated operation in unison, such as dampers used for mixing, provide the dampers with a positive pilot positioner. The positive pilot positioner shall be directly mounted to the pneumatic damper actuator and have pressure gauges for supply input and output pressures.
4. The total damper area operated by an actuator shall not exceed 80% of the manufacturer's maximum area rating. Provide at least one actuator for each damper section. Each damper actuator shall not power more than 20 ft^2 of damper.
5. Use line shafting or shaft couplings (jack shafting) in lieu of blade-to-blade linkages or shaft coupling when driving axially aligned damper sections.

3.13 WARNING LABELS

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the control 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 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.

3.14 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 2 in. of termination with control system address or termination number.

B. All pneumatic tubing shall be labeled at each end within 2 in. of termination with a descriptive identifier.

C. Permanently label or code each point of field terminal strips to show the instrument or item served.

D. Identify control panels with minimum ½ in. letters on laminated plastic nameplates.

E. Identify all other control components with permanent labels. All plug-in components shall be labeled such that label removal of the component does not remove the label.

F. Identify room sensors related to terminal boxes or valves with nameplates.

G. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

H. Identifiers shall match record documents.

3.15 CONTROLLERS

A. Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

B. Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all of the hardware points listed in Section 23 09 93 (Sequences of Operation).

3.16 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging.

B. Point Naming. Name points as shown on the equipment points list provided with each sequence of operation. See Section 23 09 93 (Sequences of Operation). If character limitations or space restrictions make it advisable to shorten the name, the abbreviations given in Appendix B to Section 23 09 93 may be used. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.

C. Software Programming.

1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:

a. Text-based:

1) Must provide actions for all possible situations
2) Must be modular and structured
3) Must be commented

b. Graphic-based:

1) Must provide actions for all possible situations
2) Must be documented

c. Parameter-based:

1) Must provide actions for all possible situations
2) Must be documented.

D. Operator Interface.

1. Standard Graphics. Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all relevant input and output points for that equipment. Also show relevant calculated points such as setpoints. As a minimum, show on each equipment graphic the input and output points and relevant calculated points as indicated on the applicable Points List in Section 23 09 93.

2. The contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

3.17 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration.

1. The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.

2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
6. Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops.
7. Alarms and Interlocks:

    a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
    b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
    c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action

3.18 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration.

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
2. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The engineer will be present to observe and review these tests. The engineer shall be notified at least 10 days in advance of the start of the testing procedures.
3. The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
4. The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
6. Demonstrate compliance with Part 1, "System Performance."
7. Demonstrate compliance with sequences of operation through all modes of operation.
8. Demonstrate complete operation of operator interface.
9. Additionally, the following items shall be demonstrated:

a. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
b. Demand limiting. The contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.
c. Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
d. Interface to the building fire alarm system.
e. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.

10. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance.

1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.
2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.19 CLEANING

A. The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.20 TRAINING

A. Provide training for a designated staff of Owner’s representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.

B. Training shall enable students to accomplish the following objectives.

1. Day-to-day Operators:

a. Proficiently operate the system
b. Understand control system architecture and configuration
c. Understand DDC system components
d. Understand system operation, including DDC system control and optimizing routines (algorithms)
e. Operate the workstation and peripherals
f. Log on and off the system
g. Access graphics, point reports, and logs
h. Adjust and change system set points, time schedules, and holiday schedules
i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
j. Understand system drawings and Operation and Maintenance manual
k. Understand the job layout and location of control components
l. Access data from DDC controllers and ASCs
m. Operate portable operator's terminals

2. Advanced Operators:

a. Make and change graphics on the workstation
b. Create, delete, and modify alarms, including annunciation and routing of these
c. Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals
d. Create, delete, and modify reports
e. Add, remove, and modify system's physical points
f. Create, modify, and delete programming
g. Add panels when required
h. Add operator interface stations
i. Create, delete, and modify system displays, both graphical and others
j. Perform DDC system field checkout procedures
k. Perform DDC controller unit operation and maintenance procedures
l. Perform workstation and peripheral operation and maintenance procedures
m. Perform DDC system diagnostic procedures
n. Configure hardware including PC boards, switches, communication, and I/O points
o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware
p. Adjust, calibrate, and replace system components

3. System Managers/Administrators:

a. Maintain software and prepare backups

b. Interface with job-specific, third-party operator software
c. Add new users and understand password security procedures

C. Organize the training into sessions or modules for the three levels of operators listed above. (Day-to-Day Operators, Advanced Operators, System Managers and Administrators). Students will receive one or more of the training packages, depending on knowledge level required.

D. Provide course outline and materials according to the "Submittals" article in Part 1 of this specification. Provide one copy of training material per student.

E. The instructor(s) shall be factory-trained and experienced in presenting this material.

F. Classroom training shall be done using a network of working controllers representative of installed hardware.

3.21 SEQUENCES OF OPERATION

A. See Section 23 09 93

3.22 CONTROL VALVE INSTALLATION

A. Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.

B. Slip-stem control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position. Ball type control valves shall be installed with the stem in the horizontal position.

C. Valves shall be installed in accordance with the manufacturer's recommendations.

D. Control valves shall be installed so that they are accessible and serviceable and so that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.

E. Isolation valves shall be installed so that the control valve body may be serviced without draining the supply/return side piping system. Unions shall be installed at all connections to screw-type control valves.

F. Provide tags for all control valves indicating service and number. Tags shall be brass, 1.5 inch in diameter, with ¼ inch high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

3.23 CONTROL DAMPER INSTALLATION

A. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.

B. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure ¼ in. larger than damper dimensions and shall be square, straight, and level.

C. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 0.3 cm (1/8 in.) of each other.

D. Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.

E. Install extended shaft or jackshaft according to manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)

F. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.

G. Provide a visible and accessible indication of damper position on the drive shaft end.

H. Support ductwork in area of damper when required to prevent sagging due to damper weight.

I. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

3.24 SMOKE DAMPER INSTALLATION

A. The contractor shall coordinate all smoke and smoke/fire damper installation, wiring, and checkout to ensure that these dampers function properly and that they respond to the proper fire alarm system general, zone, and/or detector trips. The contractor shall immediately report any discrepancies to the engineer no less than two weeks prior to inspection by the code authority having jurisdiction.

B. Provide complete submittal data to controls system subcontractor for coordination of duct smoke detector interface to HVAC systems.

3.25 DUCT SMOKE DETECTION

A. Submit data for coordination of duct smoke detector interface to HVAC systems as required in Part 1, "Submittals."

B. This Contractor shall provide a dry-contact alarm output in the same room as the HVAC equipment to be controlled.

3.26 PACKAGED EQUIPMENT CONTROLS

A. General. The electronic controls packaged with any equipment furnished under this contract shall communicate with the building direct digital control (DDC) system. The DDC system shall communicate with these controls to read the information and change the control setpoints as shown in the points list, sequences of operation, and control schematics. The information to be communicated between the DDC system and these controls shall be in the standard object format as defined in ANSI/ASHRAE Standard 135 (BACnet). Controllers shall communicate with other BACnet objects on the internetwork using the Read (Execute) Property service as defined in Clause 15.5 of Standard 135.

B. Distributed Processing. The controller shall be capable of stand-alone operation and shall continue to provide control functions if the network connection is lost.

C. I/O Capacity. The controller shall contain sufficient I/ O capacity to control the target system.

D. The Controller shall have a physical connection for a laptop computer or a portable operator’s tool.

E. Environment. The hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 40°C to 60°C (40°F to 140°F).
2. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

F. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field removable, modular terminal strips or to a termination card connected by a ribbon cable.

G. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 30 days.

H. Power. Controller shall be able to operate at 90% to 110% of nominal voltage rating.

I. Transformer. Power supply for the Controller must be rated at minimum of 125% of ASC power consumption and shall be fused or current limiting type.

3.27 START-UP AND CHECKOUT PROCEDURES

A. Start up, check out, and test all hardware and software and verify communication between all components.

1. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
2. Verify that all analog and binary input/output points read properly.
3. Verify alarms and interlocks.
4. Verify operation of the integrated system.

APPENDIX A: Glossary of Terms

Terms used within the Specification Text:

Advanced Application Controller (AAC):

A fully programmable control module. This control module may be capable of some of the advanced features found in Building Controllers (storing trends, initiating read and write requests, etc.) but it does not serve as a master controller. Advanced Application Controllers may reside on either the Ethernet/IP backbone or on a subnet.

Application Specific Controller (ASC):

A pre-programmed control module which is intended for use in a specific application. ASCs may be configurable, in that the user can choose between various pre-programmed options, but it does not support full custom programming. ASCs are often used on terminal equipment such as VAV boxes or fan coil units. In many vendors' architectures ASCs do not store trends or schedules but instead rely upon a Building Controller to provide those functions.

BACnet/IP:

An approved BACnet network type which uses an Ethernet carrier and IP addressing.

BACnet MS/TP:

An approved BACnet network type which uses a Master-Slave Token Passing configuration. MS/TP networks are unique to BACnet and utilize EIA485 twisted pair topology running at 9600 to 76,800 bps.

BACnet over ARCNET:

An approved BACnet network type which uses an ARCNET (attached resource computer network) carrier. ARCNET is an industry standard that can utilize several speeds and wiring standards. The most common configuration used by BACnet controllers is an EIA485 twisted pair topology running at 156,000 bps.

Building Controller (BC):

A fully programmable control module which is capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers. Typically this controller is located on the Ethernet/IP backbone of the BAS. In many vendors' architectures a Building Controller will serve as a master controller, storing schedules and trends for controllers on a subnet underneath the Building Controller.

Direct Digital Control (DDC):

A control system in which a digital computer or microprocessor is directly connected to the valves, dampers, and other actuators which control the system, as opposed to indirectly controlling a system by resetting setpoints on an analog pneumatic or electronic controller.

PICS - Protocol Implementation Conformance Statement:

A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device.

Smart Actuator (SA):

An actuator which is controlled by a network connection rather than a binary or analog signal. (0-10v, 4-20mA, relay, etc.)

Smart Sensor (SS):

A sensor which provides information to the BAS via network connection rather than a binary or analog signal. (0-10000 ohm, 4-20mA, dry contact, etc.)

Web services:

Web services are a standard method of exchanging data between computer systems using the XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services can be used at any level within a Building Automation System (BAS), but most commonly they are used to transfer data between BAS using different protocols or between a BAS and a non-BAS system such as a tenant billing system or a utility management system.

Terms used within the Sequences of Operation:

adj.

Adjustable by the end user, through the supplied user interface.

AI, AO, etc. (Column Headings on Points List)

AI = Analog Input. A physical input to the control module.
AO = Analog Output. A physical output from the control module.
AV = Analog Value. An intermediate (software) point that may be editable or read-only. Editable AVs are

typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only AVs are typically used to display the status of a control operation.

BI = Binary Input. A physical input to the control module.
BO = Binary Output. A physical output from the control module.
BV = Binary Value. An intermediate (software) point that may be editable or read-only. Editable BVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only BVs are typically used to display the status of a control operation.
Loop = A control loop. Most commonly a PID control loop. Typically a control loop will include a setpoint, an input which is compared to the setpoint, and an output which controls some action based upon the difference between the input and the setpoint. A PID control loop will also include gains for the proportional, integral, and derivative response as well as an interval which controls how frequently the control loop updates its output. These gains may be adjustable by the end user for control loop "tuning," but in self-tuning control loops or loops which have been optimized for a specific application the gains may not be adjustable.
Sched = Schedule. The control algorithm for this equipment shall include a user editable schedule.
Trend. The control system shall be configured to collect and display a trend log of this object. The trending interval shall be no less than one sample every 5 minutes. (Change of Value trending, where a sample is taken every time the value changes by more than a user-defined minimum, is an acceptable alternative.)
Alarm. The control system shall be configured to generate an alarm when this object exceeds user definable limits, as described in the Sequence of Controls.

Note: If the specifications require use of the BACnet protocol, all of the above shall be provided as BACnet objects.

KW Demand Limiting: *

An energy management strategy that reduces energy consumption when a system's electric power meter exceeds an operator-defined threshold.

When power consumption exceeds defined levels, the system automatically adjust setpoints, de-energizes low priority equipment, and takes other pre-programmed actions to avoid peak demand charges. As the demand drops, the system restores loads in a predetermined manner.

Occupant Override Switch, or Timed Local Override:

A control option that allows building occupants to override the programmed HVAC schedule for a limited period of time.

When the override time expires, the zone returns to its unoccupied state.

Occupant Setpoint Adjustment:

A control option that allows building occupants to adjust - within limits set by the HVAC control system - the heating and cooling setpoints of selected zones. Typically the user interface for this function is built into the zone sensor.

Optimal Start-Up: *

A control strategy that automatically starts an HVAC system at the latest possible time yet ensures comfort conditions by the time the building becomes occupied.

In a typical implementation, a controller measures the temperature of the zone and the outside air. Then, using design heating or cooling capacity at the design outside air temperature, the system computes how long a unit must run at maximum capacity to bring the zone temperature to its occupied setpoint.

The optimal start algorithm often includes a self-learning feature to adjust for variations from design capacity.

A distributed system must use Run on Request with Optimal Start. (See below.)

Requested, or Run on Request: *

A control strategy that optimizes the runtime of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service. Source equipment runs only when needed, not on a fixed schedule.

The source equipment runs when one or more receiving units request its services. An operator determines how many requests are required to start the source equipment.

For example, if all the zones in a building are unoccupied and the zone terminal units do not need heating or cooling, the AHU will shut down. However, if a zone becomes occupied or needs cooling, the terminal unit will send a run request to the AHU to initiate the start-up sequence. If this AHU depends on a central chiller, it can send a run request to the chiller.

The run on request algorithm also allows an operator to schedule occupancy for individual zones based on the needs of the occupants without having to adjust the schedules of related AHUs and chillers.

Trim and Respond, or Setpoint Optimization: *

A control strategy that optimizes the setpoint of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service.

The source unit communicates with receiving units to determine heating, cooling, and other requirements, and then adjusts its setpoint.

For example, if all zones are comfortable and do not request cooling, the AHU will gradually increase (trim) its supply air setpoint. When a zone requests cooling, the AHU responds by dropping its setpoint. The more zones that request cooling, the more it drops the setpoint. The AHU repeats this process throughout the day to keep zones cool, but with a supply air setpoint that is no cooler than necessary.

Contracting Terms:

Furnished or Provided:

The act of supplying a device or piece of equipment as required meeting the scope of work specified and making that device or equipment operational. All costs required to furnish the specified device or equipment and make it operational are borne by the division specified to be responsible for providing the device or equipment.

Install or Installed:

The physical act of mounting, piping or wiring a device or piece of equipment in accordance with the manufacturer's instructions and the scope of work as specified. All costs required to complete the installation are borne by the division specified to include labor and any ancillary materials.

Interface:

The physical device required to provide integration capabilities from an equipment vendor's product to the control system. The equipment vendor most normally furnishes the interface device. An example of an interface is the chilled water temperature reset interface card provided by the chiller manufacturer in order to allow the control system to integrate the chilled water temperature reset function into the control system.

Integrate:

The physical connections from a control system to all specified equipment through an interface as required to allow the specified control and monitoring functions of the equipment to be performed via the control system.

APPENDIX B: Abbreviations

The following abbreviations may be used in graphics, schematics, point names, and other UI applications where space is at a premium.

AC - Air Conditioning
ACU - Air Conditioning Unit
AHU - Air Handling Unit
AI - Analog Input
AO - Analog Output
AUTO - Automatic
AUX - Auxiliary
BI - Binary Input
BO - Binary Output
C - Common
CHW - Chilled Water
CHWP - Chilled Water Pump
CHWR - Chilled Water Return
CHWS - Chilled Water Supply
COND - Condenser
CW - Condenser Water
CWP - Condenser Water Pump
CWR - Condenser Water Return
CWS - Condenser Water Supply
DA - Discharge Air
EA - Exhaust Air
EF - Exhaust Fan
EVAP - Evaporators
FCU - Fan Coil Unit
HOA - Hand / Off / Auto
HP - Heat Pump
HRU - Heat Recovery Unit
HTEX - Heat Exchanger
HW - Hot Water
HWP - Hot Water Pump
HWR - Hot Water Return
HWS - Hot Water Supply
MAX - Maximum
MIN - Minimum
MISC - Miscellaneous
NC - Normally Closed
NO - Normally Open
OA - Outdoor Air
PIU - Powered Induction Unit
RA - Return Air
RF - Return Fan
RH - Relative Humidity
RTU - Roof-top Unit
SA - Supply Air

SF - Supply Fan
SP - Static Pressure
TEMP - Temperature
UH - Unit Heater
UV - Unit Ventilator
VAV - Variable Air Volume
VVTU - Variable Volume Terminal Unit
W/ - with
W/O - without
WSHP - Water Source Heat Pump

3.28 APPENDIX C: Existing Equipment to be converted to Automated Logic (ALC).

END OF SECTION 23 09 23

SECTION 23 21 14 - HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Air vents

B. Strainers

C. Pump specialties

D. Pump triple duty valve

E. Glycol specialties

F. Relief valves

G. Pressure gauges

H. Thermometers

I. Coil hookup packages

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Hydronic Piping

D. Division 26 – Electrical Wiring Systems

1.3 REFERENCES

A. ANSI/ASME – Boilers and Pressure Vessels Code

B. ASME B31.9 – Building Services Piping

1.4 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME Boilers and Pressure Vessels Code Section 8D for manufacture of tanks and air separators.

B. Conform to ASME 31.9 for materials, products and installation.

1.5 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.6 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 23 – Common Work Results for HVAC.

B. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.

C. Submit shop drawings on the following:

1. Strainers
2. Pump specialties
3. Triple duty valves
4. Coil hookup packages with independent control valves
5. Relief valves
6. Glycol specialties
7. Pressure gauges
8. Thermometers

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 23 – Common Work Results for HVAC. Submit ASME certification.

B. Include installation instruction, assembly views, lubrication instructions, and replacement parts list.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS – AIR VENTS

A. Armstrong

B. Bell and Gossett

C. Wheatley

D. Reviewed equivalent

2.2 AIR VENTS

A. Manual Type: Line sized tee with ball valve and U-shaped copper pipe for discharge into hand-held container.

B. Float Type: Cast iron body, stainless steel float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve. Bell and Gossett Model 107A Basis of Design, Metraflex MetraVent MV or reviewed equivalent.

2.3 ACCEPTABLE MANUFACTURERS – STRAINERS

A. Armstrong

B. Wheatley

C. Keckley (Basis of Design)

2.4 STRAINERS

A. Size 2 ½ inch TO 8 inch: ASTM A126 Class B Cast Iron Body, 200 psi WOG at 150°F, Class 125, Y pattern, bolted screen retainer, off center blow down fitted with gate valve and plug. Provide stainless steel perforated screen for liquid service. Keckley Style A as Basis of Design.

B. Size 2 inch and Under: Cast Bronze Body, 200 psi at 150°F, Class 125, Y pattern, screwed screen retainer, blow down fitted with gate vane and plug, threaded or screwed ends. Provide stainless steel perforated screen for liquid service. Keckley F-150 (screwed) and E-150 (solder joint) as Basis of Design.

C. Well Water Basket Strainers: Flanged carbon steel (ASTM A216, Grade WCB) body rated for 200 psig working pressure, basket pattern with 1/8 stainless steel perforation screen and 80 mesh stainless steel screen, thumbwheel cover. Keckley SGFV-K as Basis of Design.

D. 5 inch and larger Basket Strainers: Flanged carbon steel (ASTM A216, Grade WCB) body rated for 200 psig working pressure, basket pattern with stainless steel perforation screen for liquid service, thumbwheel cover. Keckley SGFV-K as Basis of Design.

2.5 ACCEPTABLE MANUFACTURERS – PUMP SPECIALTIES

A. Metraflex (Basis of Design)

2.6 PUMP SUCTION SPECIALTY

A. Combination reducing elbow, flex connector and rotational vanes. Constructed of steel reducing elbow, ANSI Class 150 flanges and Type 304 stainless steel, close pitch corrugated hose with Type 304 stainless steel outer braided covering. Provide CRV vane that imparts a rotational motion as the fluid enters the elbow and counteract elbow inducted turbulence enabling the fluid to turn uniformly and exit with a flat velocity profile. Rated for 190 psi at 70° F and 175 psi at 200° F. Metraflex CRV Flex as Basis of Design.

2.7 PUMP DISCHARGE SPECIALTY

A. Combination increaser, flex connector and straightening vanes. Construct of steel increaser, ANSI Class 150 flanges and Type 304 stainless steel, close pitched corrugated hose with Type 304 stainless steel outer braided covering. Provide carbon steel straightening vane that reduces turbulence equal to 5-10 pipe diameters of straight pipe while allowing full movement of the connector. Rated for 190 psi at 70° F and 175 psi at 200° F. Provide carbon steel reducing elbow where required. Metraflex Vane Flex as Basis of Design.

2.8 ACCEPTABLE MANUFACTURERS – TRIPLE DUTY VALVES

A. Bell and Gossett

B. Paco (Basis of Design)

C. Armstrong

D. Weinman

E. Reviewed equivalent

2.9 PUMP TRIPLE DUTY VALVE

A. Valves: Straight or angle pattern, flanged cast-iron valve body bolt-on bonnet for 175 psig operating pressure, non-slam check valve with spring-loaded bronze disc and seat, stainless steel stem, and calibrated adjustment permitting flow regulation, repacking under line pressure.

2.10 ACCEPTABLE MANUFACTURERS – RELIEF VALVES

A. Bell and Gossett

B. Kunkle (Basis of Design)

C. Watts

D. Reviewed equivalent

2.11 RELIEF VALVES

A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labeled.

2.12 GLYCOL SYSTEM

A. Mixing Tank: 50 gallon polyethylene tank, 1/3 hp gear pump (120V-1 phase) with strainer, NEMA 4X control panel (120V-1 phase) with power switch and light, HOA switch for pump, low level light and 15A fuse. Provide PVC tubing and fittings, PVC ball valve and cast iron Y-strainer on the suction assembly; and Schedule 80 PVC pipe and fittings, PVC ball valve, PVC check valve, pressure gauge and ASME rated brass body pressure relief valve with tubing return to tank on the discharge assembly of each unit. For feeders supplying glycol solutions to heating systems; then the piping and fittings shall be Type S, Schedule 40 steel or Type L copper; provide dielectric fittings between dissimilar metal interfaces and between discharge assembly and system connection. Manufacturer: JL Wingert GL-50E1, or reviewed equivalent.

B. Glycol Solution: Inhibited propylene glycol and water solution mixed 30% by volume. Amrep AmTerm 9030, or reviewed equivalent.

2.13 ACCEPTABLE MANUFACTURERS – PRESSURE GAUGES

A. Ashcroft 1009 (Basis of Design)

B. Trerice 600CB

C. Miljoco P4598L

D. Weksler EA14

E. Weiss 4CTS-1

F. Reviewed equivalent

2.14 PRESSURE GAUGES

A. Gauges shall be ASME B40-100, 4-1/2" diameter, stainless steel case, bronze bourbon tube, brass socket, acrylic/glass window, white dial with black pointer and numbers, liquid filled, 1% of full span accuracy, provide pressure, snubber, union and shut-off.

B. For liquid fill, verify liquid and gauge compatibility for the operating temperature of the measured medium. Provide appropriate liquid fill: Glycerin for temperatures from 30 - 150°F, silicone for temperatures -30 to 240°F.

C. Range: Comply with the following

1. Vacuum: 30 inches Hg of vacuum to 15 psig pressure.
2. Fluids under Pressure: Two times operating pressure.

2.15 ACCEPTABLE MANUFACTURERS – THERMOMETERS

A. Trerice BX (Basis of Design)

B. Miljoco SX935

C. Weksler AA5H-9

D. Weiss 9VU

E. Reviewed equivalent

2.16 THERMOMETERS

A. ASTM E1, industrial type, glass tubing, red reading, 9" long, cast aluminum with chrome front double strength glass, adjustable angle, organic liquid filled with magnifying lens, extended neck to clear insulation. Provide wells and separable sockets and oil or graphite heat transfer liquid.

B. Scale Range:

1. Hot Water: 30 to 240° F with 2° F scale division.
2. Glycol: (Verify Operating Temperatures of System) Cold Water Only: (-) 40 to 110°F, Drycooler water loop with economizer operation: Custom Range (-) 20 to 180°F.

2.17 COIL HOOKUP PACKAGES WITH PRESSURE INDEPENDENT CONTROL VALVES

A. Provide for each coil a combination valving package from one manufacturer throughout.

B. For the supply water line; provide a combination inlet shutoff valve/PT plug/ Y-strainer with blowdown valve and 20 mesh stainless steel screen/union and on the return line; a combination union/PT plug, pressure independent control valve and shutoff valve.

C. Connections shall be sweat 2" and below and flanged 2 1/2" and above.

D. Shutoff valves shall be full port bronze ball type for 2" and below rated at 300 psi at 265° F and butterfly type for 2 1/2" and above rated at 200 psi WP at 250° F. Ball valves shall have extension kit, nylon coated lever handle, Teflon seats and seals, blow-out proof shafts and double shaft seals. Butterfly valves shall be lug pattern, cast iron body, EPDM cartridge seat, one-piece Type 416 stainless steel shaft, lever operator for 6" and below, worm-gear operator for 8" and above.

E. Acceptable Manufacturers: Nexus, FDI, Armstrong, Tour & Anderson or reviewed equivalent

F. Control Valves: Factory fabricated pressure independent with internal differential pressure regulator which automatically adjusts to normal changes in system pressure and provides 100 percent control valve authority at all positions of the valve and maintain proportional/linear flow coil characteristics and maintain a linear flow characteristic, accurately control the flow from 0-100 percent full rated flow with an operating pressure differential range of 2.3 to 60 psi., FCI 70-2 Class 4 shut-off on all sizes and field serviceable. Control valve shall incorporate control, dynamic system balancing and flow limiting. Hydronic system pressure independent control valve bodies shall meet ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure and shall have the following characteristics:

1. Valves: Sized for maximum circuit flow rate, generally line sized.

    a. Flow setting of the valves shall be by simple percentage of maximum flow available on the valve.

        1) Valves requiring the use of presetting graphs to determine the percentage of flow to preset on the valve shall not be acceptable.

2. Generally line sized. NPS 2 and Smaller: Class 150 bronze or brass body with union connections, stainless steel trim trim, stainless steel rising stem, stainless steel disc or ball, and screwed ends with backseating capacity repackable under pressure.
3. NPS 2-1/2 and Larger: Class 125 iron or ductile iron body, stainless steel trim, stainless steel rising stem, stainless steel disc or ball, flanged ends with backseating capacity repackable under pressure.
4. Pressure Control Seat: Brass construction with vulcanized EPDM.

    a. Internal components made of Plastics shall NOT be acceptable.

5. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head.

    a. 1/2” thru 1-1/4” shall possess a Close-off rating of at least 130 psi
    b. 1-1/2” thru 10” shall possess a Close-off rating of at least 260 psi

6. Valves shall be manufactured by one manufacturer throughout the project.
7. Valves requiring removal of the Differential Pressure Regulation Cartridge prior to Flushing or initial system cleaning and re-installation after flushing shall not be acceptable.

G. Electronic Actuators: Direct-mounted self-calibrating type designed for minimum 60,000 full-stroke cycles at rated force and shall be from the same manufacturer as the pressure independent control valve; branded or 3rd party actuators must be submitted and approved prior to bid. The actuator shall provide visible position indication. Fail positions on power failure shall include in-place, open or closed as noted in the ATC / BAS controls specifications.

1. Coordinate first subparagraph and list below with Part 2 "Manufacturers" Article. Retain "Available" for nonproprietary and delete for semi-proprietary specifications. If list does not include manufacturers of systems that make or market this equipment under their own name, those manufacturers' names may be added. List can be deleted if it is not important that specific manufacturers be named for this product.
2. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
3. Fail-Safe Operation: Shall be Mechanical, spring-return mechanism; or Capacitance Driven. Power Requirements (Two-Position Spring Return): 24-V ac.
4. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
5. Proportional Signal: 0 to 10Vdc or 2 to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.

6. Actuator force shall be capable of providing the valve close-off rating.

    a. 1/2” thru 1-1/4” shall possess a Close-off rating of at least 130psi
    b. 1-1/2” thru 10” shall possess a Close-off rating of at least 260 psi

7. Temperature Rating: -36° to 140° F.

H. 3rd Party Test Results: The manufacturer shall submit in his submittal documentation package a set of 3rd Party test reports from a recognized testing agency verifying the accuracy and operation of the submitted valves and associated actuators. Separate reports for valves and actuators will not be acceptable.

I. Acceptable Manufacturers:

1. Danfoss.
2. Flow Control Industries, Inc.
3. Tour & Anderson
4. Reviewed Equivalent

PART 3 - EXECUTION

3.1 INSTALLATION AND APPLICATION

A. Install specialties in accordance with manufacturer's instructions to permit intended performance.

B. Provide manual air vents at system high points, at end of mains, at terminal return runouts and wherever are needed to purge entrained air. Provide automatic air vents where indicated.

C. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.

D. Provide pump specialties for centrifugal pumps.

E. Provide pump triple valve on discharge side of constant speed base mounted centrifugal pumps. For VFD driven pumps, substitute a silent check valve and isolation valve.

F. Support pump suction specialty with floor (base) mounted pipe and flange supports.

G. Provide coil hookup packages with pressure independent control valves for each terminal unit, rooftop unit coils, rooftop unit condensers, heat pumps (chilled, hot geothermal) and where temperature or pressure control is necessary for satisfactory system operation, thermal comfort and control.

H. Provide pressure relief valves on pressure vessels (including but not limited to) expansion tanks, buffer tanks, heat exchangers, and boilers.

I. Select system pressure relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment pressure relief valve capacity to exceed rating of connected equipment.

J. Pipe pressure relief valve outlet to nearest floor drain or trench drain. Piping shall be supported so that no stress is induced on the pressure relief valve.

K. Perform tests determining strength of propylene glycol and water solution and submit written test results. Perform tests after system has been operating for a minimum of 24 hours.

L. Provide isolation valves and balance valves at return line locations where branches tap off mains and sub-branches or as required for proper system isolation and balance and for future isolation and balancing ease due to building renovations. Provide isolation valves and balance valve at taps from risers at each floor.

M. Locate specialties at accessible locations.

N. Provide pressure gauges at the suction and discharge of each pump, heat exchangers, filters, coils, etc. and where else required to monitor, troubleshoot and measure system water pressures; where indicated on the plans (or not) and control drawings. Provide additional snubber, as required to steady gauge readings. Locate gauges where dials can be easily read; provide pressure gauge cabinet where required for ease of reading.

O. Provide thermometers and pressure gauges at heat exchanger supply and return, where pipes enter and exit mechanical rooms and where else required to monitor, troubleshoot and measure system water temperatures and pressures and where indicated on the plans (or not) and control drawings. Locate thermometers and pressure gauges where temperatures can be easily read. Locate thermometers where temperatures can be easily read.

P. Provide thermometers at all main air handling unit coil runouts, heat exchanger supply and return (both sides), at mixing valve locations, at mains entering or leaving mechanical rooms and where else required to monitor and measure system water temperatures and where indicated on the plans (or not) and control drawings. Locate thermometers where temperatures can be easily read. Locate thermometers where temperatures can be easily read.

Q. Provide strainers at inlet of pumps, control valves, on main lines, incoming water service (PRV) and where needed and not indicated on the diagrammatic plans. Provide a blowdown valve with capped chain and hose bibb at each strainer.

R. Provide specialties in accordance with details on the drawing and as required per manufacturer’s recommendations and code regulations.

END OF SECTION 23 21 14

SECTION 23 21 16 - HYDRONIC PIPING AND VALVES (ABOVE GRADE)

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Pipe and pipe fittings

B. Valves

C. Heating water piping system

D. Glycol piping system

E. Chilled water piping system

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Hydronic Specialties

D. Division 23 – Expansion Compensation

E. Division 23 – Hangers and Supports for HVAC Piping and Equipment

F. Division 23 – Piping Insulation

G. Division 23 – Chemical Water Treatment

1.3 REFERENCES

A. ANSI/ASME – Boiler and Pressure Vessel Code

B. ANSI/ASME Sec 9 – Welding and Bracing Qualifications

C. ANSI/ASME B16.3 – Malleable Iron Threaded Fittings Class 150 and 300

D. ANSI/ASME B31.9 – Building Services Piping

E. ANSI/AWS A5.8 – Brazing Filler Metal

F. ANSI/AWS D10.9 - Specifications for Qualification of Welding Procedures and Welders for Piping and Tubing.

G. ASTM A53 – Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless

H. ASTM A234 – Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

I. ASTM B32 – Solder Metal

J. ASTM B88 – Seamless Copper Water Tube

1.4 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME B31.9.

1.5 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Welding Materials and Procedures: Conform to ANSI/ASME Sec. 9.

C. Welders Certification: In accordance with ANSI/ASME Sec. 9.

1.6 SUBMITTALS

A. Submit product data under provisions of Division 23 – Common Work Results for HVAC.

B. Include data on pipe materials, pipe fittings, valves, and accessories.

C. Include welder's certification of compliance with ANSI/ASME Sec. 9.

1.7 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver, store, protect and handle products under provisions of Division 23.

B. Protect piping and specialties from contamination by leaving in shipping containers with all caps/plugs in place until time of immediate installation.

PART 2 - PRODUCTS

2.1 HEATING WATER, CHILLED WATER, GLYCOL PIPING ABOVE GRADE

A. Steel Pipe: ASTM A53, Type ERW, Grade B, Schedule 40 for 10" and below, Standard (.375" wall) for 12" and above (both for welded joints). Use ASTM A53 or 120, Type S, Grade B, Schedule 40 for screwed joints.

1. Fittings: ANSI/ASTM B16.3, malleable iron Class 150 or ASTM A234, wrought steel welding type fittings, Schedule 40.
2. Joints: Up to 2 inch, screwed; 2-1/2 inch and up, welded. Utilize fittings as specified above.

B. Copper Tubing: ASTM B88, Type L, hard drawn, 2-1/2" and below.

1. Fittings: ANSI/ASME B16.23 cast brass or ANSI/ASME B16.29 solder wrought copper.
2. Joints: ASTM B32, solder, Grade 95TA. Utilize fittings as specified above.

2.2 EQUIPMENT DRAINS AND OVERFLOWS

A. PVC cannot be used in plenum areas.

B. Steel Pipe: ASTM A53, Schedule 40 galvanized.

1. Fittings: Galvanized cast iron, or ANSI/ASTM B16.3 malleable iron.
2. Joints: Screwed, or grooved mechanical couplings, drainage pattern.

C. Copper Tubing: ASTM B88, Type L hard drawn.

1. Fittings: ANSI/ASME B16.23 cast brass, or ANSI/ASME B16.29 solder wrought copper, drainage pattern.
2. Joints: ASTM B32, solder, Grade 95TA.

2.3 FLANGES AND UNIONS

A. Unions (non-dielectric)

1. 2" and Smaller – Standard weight, all brass, ground joint, sweat ends for use in copper and brass lines. Standard weight, malleable iron, ASME B16.39, ground type with brass seat ring, pressure rating per pipe fittings and application; threaded ends for use in steel lines.
2. 2 1/2" and Larger – Standard weight, all brass, flanged pattern, gasket type, with brass bolts and nuts, sweat ends for use in copper and brass lines. Standard weight, black steel, flanged pattern, gasket type, with steel bolts and nuts, pressure rating per pipe fittings and application, threaded ends for use in steel lines.
3. All unions shall conform to the requirements set forth per ASME B31.1 and B31.9.

B. Flanges – Faced true, flat face or raised face type as indicated, welding type for welded lines, screwed type for threaded lines, pressure rating as required by service per ASME B16.5, B31.1

and B31.9. Flanges shall be flat or raised face type to match and be compatible with flange construction at equipment and valves.

1. Threaded lines – ASME B16.1 with ASME B1.20.1 threads, face and pressure rating per service per ASME requirements, screwed ends.
2. Welded lines – ASME B16.5, face and pressure rating per service per ASME requirements, forged steel, slip-on welding (front and back) type. Utilize ASME B16.5, forged steel, welding neck type for high pressure steam (above 99 psig) and high temperature hot water service; both with pressure rating per service per ASME requirements.
3. Flange hardware – ASTM B18.2.1 carbon steel, threaded bolts and nuts, per ASME requirements.

2.4 WELDED FITTINGS (STEEL PIPING SYSTEMS)

A. Service class specified herein, beveled end, butt welding type, long radius type elbows, full size (straight) or reducing outlet type welding tees, concentric reducers, return bends, caps.

2.5 PIPE NIPPLES

A. Non-dielectric type – Extra heavy pipe of same material of adjacent installed pipe.

B. Dielectric type – Electroplated steel pipe with thermoplastic lining, threaded ends, rated for minimum 300 psig and 225 service.

2.6 DIELECTRIC UNIONS

A. Provide at copper (non-ferrous) to ferrous metal interface locations. Temperature and pressure rating of union shall equal or exceed the maximum temperature and pressure in which the union is installed. Dielectric unions shall be screwed for use in threaded lines, sweat for use in soldered lines or welded neck flanged ends for use in welded lines and shall withstand 600V on a dry line without flash-over. Central Plastic, EPCO Sales, Watts or reviewed equivalent.

2.7 GASKETS

A. Ring type – ASME B16.21, 1/16" thick, factory cut, compressed, heat resistant for intended service, pressure rating per the intended service. All gaskets for flanges shall conform to the requirements set forth per ASME 31.1 and 31.9. Garlock or reviewed equivalent.

2.8 MECHANICAL WALL SEALS

A. Provide mechanical wall seals at pipe penetrating exterior walls below grade or at pipe penetrating slabs in contact with grade. Seals shall be modular synthetic rubber type (low or high temp depending upon the pipe application) with interlocking links and mechanical compression via Type 316 stainless steel hardware. Thunderline "Link-Seal", Metraflex "MetraSeal" or reviewed equivalent by Wayne or Michigan.

B. Pipe sleeves – ASTM A53, standard weight steel pipe, hot dipped galvanized finish.

C. Escutcheon plates – 1 piece or split hinge plates, steel for unfinished locations. Polished stainless steel or chrome plated copper plates, 1 piece or split hinge for exposed locations.

2.9 ACCEPTABLE MANUFACTURERS – GATE VALVES

A. Crane

B. Nibco

C. Stockham

D. Powell

2.10 GATE VALVES

A. 2" and Smaller: Class 125, 200 CWP or Class 150, 300 psi CWP, ASTM B62 cast bronze body and bonnet, rising stem, union bonnet, solid wedge disc, asbestos-free packing, malleable iron handwheel, MSS-SP-80. Non-rising stem valves can be used only where there is insufficient room for a rising stem valve.

1. Class 125 – Stockham B-100 (threaded), B-108 (solder), rising stem
B-103 (threaded), B-104 (solder), non-rising stem
2. Class 150 – Stockham B-120 (threaded), B-125 (solder), rising stem
B-128 (threaded), non-rising stem

B. 2 1/2" and Larger: Class 125, 200 psi CWP, ASTM A126B cast iron body and bonnet, rising stem, flanged ends, outside screw and yoke, solid wedge disc, bronze trim, packing and gasket shall be asbestos free, malleable iron handwheel, MSS-SP-70. Non-rising stem valves can be used only where there is insufficient room for a rising stem valve.

1. Stockham G-623 and Stockham G-612.

2.11 ACCEPTABLE MANUFACTURERS – GLOBE VALVES

A. Crane

B. Nibco

C. Stockham

D. Powell

2.12 GLOBE VALVES

A. 2" and Smaller: Class 125, 200 psi CWP, or Class 150, 300 psi CWP, ASTM B62 cast bronze body and bonnet, rising stem, renewable seat and disc, bronze stem, PTFE disc, asbestos free packing, malleable iron handwheel, MSS-SP-80.

1. Class 125 – Stockham B-13T (threaded) or BT-14T (solder)
2. Class 150 – Stockham B-22T (threaded) or BT-20T (solder)

B. 2 1/2" and Larger: Class 125, 200 psi CWP, ASTM A-126B cast iron body and bolted bonnet, rising stem, bronze trim, renewable seat and disc, outside screw and yoke, flanged ends, asbestos free packing and gasket material, malleable iron handwheel, MSS-SP-85.

1. Stockham G-512 (straight pattern)
2. Stockham G-515 (angle pattern)

2.13 ACCEPTABLE MANUFACTURERS – BALL VALVES

A. Conbraco

B. Nibco

C. Jamesbury

2.14 BALL VALVES

A. 3" and Smaller: 150 psig WSP, 600 psig CWP, ASTM B584 bronze body, 2 piece design, full port, Type 316 stainless steel vented ball and stem, PTFE seats, extended lever handle with vinyl cover, MSS-SP-110.

1. Nibco S-585-70-66 (solder)
2. Nibco T-585-70-66 (threaded)

2.15 ACCEPTABLE MANUFACTURERS – BUTTERFLY VALVES

A. Nibco

B. Centerline

C. Stockham

D. DeZurik

2.16 BUTTERFLY VALVES

A. 2" and Larger: 200 psig WOG, bubble tight shutoff, ASTM A126 cast iron full lug body, 4" and below, ASTM A536 grade 65-45-12 ductile iron full lug body 5" and above, nickel-plated ductile iron disc, extended neck, Type 416 stainless steel stem, lubricated bronze stem bushings (3), phemolic reinforced EPDM seat, Bung-N shaft seal, 10 position lever handle for valves 6" and smaller, manual gear operator and handwheel for valves 8" and up, MSS-SP-67. Butterfly valves used for motorized isolation shall have a motorized actuator (with full close-off pressure to act against pump head) and manual override handwheel.

1. Stockham LG-712-BS3-E-M (lever handle), 4" and below
2. Stockham LD-712 (lever handle for 5" and 6")
3. Stockham LD-722 (gear operator, 8" and above)

2.17 ACCEPTABLE MANUFACTURERS – SWING CHECK VALVES

A. Crane

B. Stockham

C. Nibco

D. Powell

2.18 SWING CHECK VALVES

A. 2" and Smaller: Class 125, 200 psi CWP or Class 150, 300 psi CWP Y-pattern horizontal flow, ASTM B62 bronze body, regrinding type, replaceable disc, MSS-SP-80.

1. Class 125 – Stockham B-320TY (threaded), B-309Y (solder)
2. Class 150 – Stockham B-321 (threaded)

B. 2 1/2" and Larger: Class 125, 200 psig CWP, ASTM A126 gray iron body and bolted bonnet, regrinding type, flanged ends, clear or full waterway, bronze trim, asbestos free gasket, MSS-SP-71.

1. Stockham G-931

2.19 ACCEPTABLE MANUFACTURERS - SPRING LOADED CHECK VALVES

A. Metraflex (Basis of Design)

B. Reviewed equivalent

2.20 SPRING LOADED CHECK VALVES

A. General: Valves shall be globe style. Valves shall have a cracking pressure of 1/4 to 1/2 psi, and fully open at a flow velocity of 4 FPS. Valve operation shall not be affected by installation position. Valve shall be capable of fully closing prior to reversal of flow and shall eliminate water hammer.

B. 2" and Smaller: ASTM B-145-5A, bronze body, brass stem, beryllium copper spring, Teflon disc, stainless steel seat screw, 250 psig non-shock WOG, 250° F max temperature, threaded ends.

1. Metraflex Style BSN (Basis of Design)
2. Reviewed equivalent

C. 2 1/2" and Larger: Class 125, ASTM A48 cast iron body, bronze seat and disc, stainless steel spring, flanged ends, Buna-N shaft seal, 190 psig non-shock WOG at 200° F.

1. Metraflex Style 900 (Basis of Design)
2. Reviewed equivalent

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe. Use emery cloth to remove oxidation at joint locations on copper tubing and fittings.

B. Remove scale and dirt on inside and outside before assembly.

C. After completion, flush, clean, rinse, clean strainers, and refill system.

3.2 INSTALLATION

A. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.

B. Water piping shall be tapped off the bottom of the pipe; provide all valves, tees, piping insulation, elbows and swing joints as required for hookup to coils or branches required by this work whether they are indicated on the drawings or not.

C. Install piping to conserve building space, and not interfere with use of space and other work.

D. Group piping whenever practical at common elevations.

E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

F. Provide clearance for installation of insulation, and access to valves and fittings.

G. Provide access where valves and fittings are not exposed.

H. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

I. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

J. Do not run piping through transformer vaults or other electrical or electronic equipment spaces and enclosures. Maintain 42" clearance from switchboards, panelboards and motor control centers.

K. Mount all control valves, sensors, flow meters and devices under other sections.

L. Connect to Equipment.

M. Connect chemical treatment to system. Refer to Division 23 and details.

3.3 PIPE CLEANING

A. Add cleaner to closed systems at concentration as recommended by manufacturer.

B. Hot Water Heating Systems: Apply heat while circulating, slowly raising temperature to 160° F and maintain for 12 hours minimum. Remove heat and circulate to 100° F or less; drain systems as quickly as possible and refill with clean water. Circulate for 6 hours at design temperatures, then drain. Refill with water and repeat until system cleaner is removed.

C. Remove, clean and replace strainer screens.

D. Systems Cleaner - Materials

1. Degreaser: Concentrated liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products; sodium tripoly phosphate and molybdate such as AmSolv 9350 or approved equal.
2. Algaecide: chlorine release agents such as sodium hypochlorite or calcium hypochlorite, or microbiocides such as quaternary ammonia compounds, tributyl tin oxide, methylene bis thiocyanate, or isothiazolones.

E. Provide all additional valves, piping, hoses etc. required to clean and flush the system.

3.4 APPLICATION

A. Install unions or flanges downstream of valves and at equipment or apparatus connections.

B. Provide 3/4 inch gate or ball drain valves at, low points of piping, bases of vertical riser, and at equipment drain locations.

C. Provide chain operators on all valves mounted above 7'-0" in equipment rooms.

D. Use gate or ball valves for isolation and shut off service on heating water systems.

E. Use gate, butterfly or ball valves for isolation and shut off service on glycol systems.

F. Use steel pipe for heating, and glycol systems. Copper pipe may be used for runouts to equipment 1 inch and smaller and main loop piping less than three (3) inches in diameter or less.

G. Provide isolation valves on equipment requiring isolation for service and/or removal use application as specified in parts D and E above.

H. Install isolation gate valves for shut-off and to isolate equipment, part of systems or vertical risers. Provide isolation valves at piping mains and changes of direction, at branches, sub-branches, where pipes enter of leave mechanical rooms, where isolation is required or needed; all this whether or not they are shown on the plans.

I. Provide manual air vents on all system high points and at individual runouts to terminal equipment and coils. Provide on return piping runouts only and equip with U-tube to discharge into drain can while piping system. Provide as required to purge air entrapment from system.

3.5 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 after all cleaning procedures are finished, 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 and maximum 200 psig. 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.

END OF SECTION 23 21 16

SECTION 23 31 13 - DUCTWORK

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Low pressure ductwork

B. Medium and high pressure ductwork

C. Double wall ductwork

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Supports and Anchors: Sleeves

D. Division 23 – Duct Insulation

E. Division 23 – Ductwork Accessories

1.3 REFERENCES

A. ASHRAE – Handbook 1989 Fundamentals; Chapter 33 – Duct Design

B. ASHRAE – Handbook 1988 Equipment; Chapter 1 – Duct Construction

C. ASTM A 90 – Weight of coating of Zinc-Coated (Galvanized) Iron or Steel Articles

D. ASTM A 167 – Stainless and Heat Resisting Chromium Nickel Steel Plate, Sheet, and Strip

E. ASTM A 525 – General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

F. ASTM A 527 – Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality

G. ASTM B209 – Aluminum and Aluminum Alloy Sheet and Plate

H. NFPA 90A – Installation of Air Conditioning and Ventilating Systems

I. NFPA 90B – Installation of Warm Air Heating and Air Conditioning Systems

J. NFPA 96 – Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooling Equipment

K. SMACNA – Duct Construction Standards

L. UL 181 – Factory-Made Air Ducts and Connectors

1.4 DEFINITIONS

A. Duct Sizes: Inside clear dimensions. For lined ducts, main sizes inside lining.

B. Low Pressure: Three pressure classifications: 1/2 inch WG positive or negative static pressure and velocities less than 2,000 fpm; 1 inch WG positive or negative static pressure and velocities less than 2,500 fpm and 2 inch WG positive or negative static pressure and velocities less than 2,500 fpm.

C. Medium Pressure: Three pressure classification: 3 inch WG positive or negative static pressure and velocities less than 4,000 fpm, 4 inch WG positive static pressure and velocities greater than 2,000 fpm, 6 inch WG positive static pressure and velocities greater than 2,000 fpm.

D. High Pressure: 10 inch WG positive static pressure and velocities greater than 2,000 fpm.

1.5 REGULATORY REQUIREMENTS

A. Construct ductwork to NFPA 90A and NFPA 96 standards.

1.6 SUBMITTALS

A. Submit shop drawings under provisions of Division 01 and 23.

B. Indicate duct fittings, particulars such as gages, sizes, welds, and configuration prior to start of work. Provide detailed layout drawings showing each duct fitting. The minimum acceptable scale is 1/4 inch equals 1 foot.

C. Provide mockups of ductwork indicating construction, sealing methods, reinforcement and methods, longitudinal and traverse joint methods, elbows with turning vanes, fittings, volume/smoke/fire/combination fire/smoke dampers installation and appurtenances. Mockups may be actual ductwork segments utilized for the project. Mockups are subject to analysis by the Engineer for conformance to these specifications and details on the contract documents.

D. Structural steel fabricator and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings, roof hatches, smoke hatches, duct through roof penetrations, expansion joints, etc.) Exact sizes and exact locations of all openings are to be verified with the approved shop drawings issued for the installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. Sizes and locations indicated on Contract Drawings are diagrammatic and for information only. Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacturer and must be repaired, relocated, alatered, replaced, reinstalled or modified in any manner will be done to the satisfaction of the Owner with no additional cost to the Owner or design professional.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Non-combustible or conforming to requirements for Class 1 air duct materials, or UL 181.

B. Actual gauge sheetmetal shall be utilized for ductwork. Sheetmetal that is out of tolerance shall not be used on the project.

C. Steel Ducts: ASTM A 527 galvanized steel sheet, lock-forming quality, having zinc coating of .90 oz. per sq. ft. for each side in conformance with ASTM A90. Ductwork that is exposed for painting shall be galvannealed.

D. Insulated Flexible Ducts: Flexible duct wrapped with flexible glass fiber insulation, enclosed by seamless aluminum pigmented plastic vapor barrier jacket; maximum 0.23 K value at 75 degrees F, R-8. 10 year parts and labor warranty against blow-out. Thermaflex G-KM. Provide insulated Thermaflex FlexFlow elbows at diffuser locations.

E. Stainless Steel Ducts: ASTM A167, Type 304 #4 finish for exposed ductwork, 2D finish for concealed ductwork.

F. Fasteners: Rivets, bolts, or sheet metal screws.

G. Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; heavy mastic, water-based, less than 50/25 smoke developed/flame spread per ASTM E84. Ductmate Pro Seal.

H. Hanger Rod: Steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

I. Seal all ducts in accordance with SMACNA Duct Construction Standards. 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 shall not be permitted as a sealant on any metal ducts. Utilize Pittsburg lock longitudinal seams for rectangular ducts and fittings through 18 gauge material. Utilize welded seams for rectangular ducts 16 gauge and up.

J. Duct hangers and supports shall be in accordance with the SMACNA HVAC DUCT CONSTRUCTION STANDARDS - METAL AND FLEXIBLE. Ducts shall be supported with approved hangers at intervals not exceeding 10 feet or by any other approved hangers systems designed in accordance with the International Building Code. Flexible and other factory made ducts shall be supported in accordance with the manufacturer's installation instructions.

2.2 LOW PRESSURE DUCTWORK

A. Fabricate and support in accordance with SMACNA Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated herein. Utilize heavier duct gauges with no stiffeners required whenever possible, in compliance with SMACNA Duct Construction Standards. Use of lighter duct gauges with stiffeners shall not be used unless approved by the Engineer prior to installation.

B. Size round and oval ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular, oval and round ducts. No variation of duct configuration or sizes permitted except by written permission.

C. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on the inside radius. Where not possible and where rectangular elbows are used, provide Aero Dyne HEP turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.

E. Provide easements where low pressure ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two duct maintaining original duct area.

F. Connect flexible ducts to metal ducts with draw bands.

G. Use double nuts and lock washers on threaded rod supports.

H. All longitudinal joints shall be of the Pittsburgh lock type. Provide an additional application of sealant on the airstream side of the joint of all ducts.

I. Use Buckley ATMD fittings on taps to diffusers. Fittings to have adhesive neoprene gasket, integral volume damper and extended neck/quadrant lock. Secure with multiple sheetmetal screws.

2.3 MEDIUM AND HIGH PRESSURE DUCTS

A. Fabricate and support in accordance with SMACNA Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated herein. Utilize heavier duct gauges with no stiffeners required whenever possible, in compliance with SMACNA Duct Construction Standards. Use of lighter duct gauges with stiffeners shall not be used unless approved by the Engineer prior to installation.

B. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide (airfoil) turning vanes; refer to Div 23 Ductwork Accessories for turning vane specifications.

C. Transform duct sizes gradually, not exceeding 15 degrees divergence and 30 degrees convergence.

D. Duct mate joints shall be used on supply, return and exhaust. Apply sealant to inside and outside of flange joint/duct joint.

E. Provide standard 90 degree lateral wye takeoffs with 45 degree inlet edge. Conical tee connections may be used.

F. Round and oval ductwork may be used in lieu of rectangular. Air velocity may not be increased. Acceptable manufacturer is United McGill. Clearances must be verified and considered where conflicts occur.

G. Use double nuts and lock washers on threaded rod supports.

H. All longitudinal joints shall be of the Pittsburgh lock type, with appropriate sealant applied to the joint during assembly. Apply another application of sealant on the airstream side of the joint.

I. Use Buckley M-BM fittings on taps to CV or VAV boxes. Fittings to have neoprene gasket and mini-bellmouth tap configuration. Secure to duct with multiple sheetmetal screws.

2.4 DUCT CONSTRUCTION STANDARDS

A. Pressure Class: 1” WG Pos. or Neg.

Material:	Galvanized, G90 grade
Standard Joint:	55 ¾” (18 gauge – 24 gauge)
Seams:	Longitudinal Pittsburgh seams for all ducts and fittings All longitudinal seams sealed.
Joint Types:	8” Duct dimension or less: S-Lock and Drive Greater than 8” dimension: TDF flange and gasket. No additional reinforcement unless noted.
Duct Reinforcing:	¾” EMT conduit & Condu-Lock, Max spacing 30” on center.

DUCT GAUGE/REINFORCEMENT					
Duct Dimension	Duct Length				
	49" – 60"	37" – 48"	31" – 36"	25" – 30"	24" - Down
30" – Down	24	24	24	24	24
31" – 36"	24	24	24	24	24
37" – 42"	24	24	24	24	24
43" – 48"	A	24	24	24	24
49" – 54"	A	A	24	24	24
55" – 60"	A	A	22	24	24
61" – 72"	B	B	22	22	22
73" – 84"	J	J	C	C	C
85" – 96"	F	J	E	E	C
97" – Up	\\\\\	H	G	G	G

1. 24 ga with tie-rods in center
2. 22 ga with tie-rods in center
3. 22 ga with tie-rods in ends
4. 22 ga with tie-rods in center and ends
5. 20 ga with tie-rods in ends
6. 20 ga with tie-rods in center and ends
7. 18 ga with tie-rods in ends
8. 18 ga with tie-rods in center and ends

J. 18 ga with no reinforcement or 22 ga with tie-rods in center and ends

B. Pressure Class: 2" WG Pos. or Neg.

Material: Galvanized, G90 grade

Standard Joint: 55 ¾" (18 gauge – 24 gauge)

Seams: Longitudinal Pittsburgh seams for all ducts and fittings
All longitudinal seams sealed.

Joint Types: 8" Duct dimension or less: S-Lock and Drive
Greater than 8" dimension: TDF flange and gasket.
No additional reinforcement unless noted.

Duct Reinforcing: ¾" EMT conduit & Condu-Lock,
Max spacing 30" on center.

DUCT GAUGE/REINFORCEMENT					
Duct Dimension	Duct Length				
	49” – 60”	37” – 48”	31” – 36”	25” – 30”	24” - Down
26” – Down	24	24	24	24	24
27” – 28”	24	24	24	24	24
29” – 30”	24	24	24	24	24
31” – 36”	22	24	24	24	24
37” – 42”	20	22	24	24	24
43” – 48”	18	20	22	22	24
49” – 54”	J	J	20	22	22
55” – 60”	D	J	20	20	22
61” – 72”	H	D	J	J	18
73” – 84”	\\\\\	D	E	C	C
85” – 96”	\\\\\	G	G	E	E
97” – Up	\\\\\	\\\\\	G	G	G

1. 24 ga with tie-rods in center
2. 22 ga with tie-rods in center
3. 22 ga with tie-rods in ends
4. 22 ga with tie-rods in center and ends
5. 20 ga with tie-rods in ends
6. 20 ga with tie-rods in center and ends
7. 18 ga with tie-rods in ends
8. 18 ga with tie-rods in center and ends

J. 18 ga with no reinforcement or 22 ga with tie-rods in center and ends

C. Pressure Class: 3” WG Pos. or Neg.

Material: Galvanized, G90 grade

Standard Joint: 55 ¾” (18 gauge – 24 gauge)

Seams: Longitudinal Pittsburgh seams for all ducts and fittings
All longitudinal seams sealed.

Joint Types: TDF flange and gasket.
No additional reinforcement unless noted.

Duct Reinforcing: ¾” EMT conduit & Condu-Lock,
Max spacing 30” on center.

DUCT GAUGE/REINFORCEMENT					
Duct Dimension	Duct Length				
	49” – 60”	37” – 48”	31” – 36”	25” – 30”	24” - Down
12” – Down	24	24	24	24	24
13” – 18”	24	24	24	24	24
19” – 26”	24	24	24	24	24
27” – 28”	22	24	24	24	24
29” – 30”	22	A	24	24	24
31” – 36”	20	22	22	24	24
61” – 72”	D	D	C	C	22
73” – 84”	\\\\\	D	G	E	C
85” – 96”	\\\\\	F	G	G	E
97” – Up	\\\\\	\\\\\	\\\\\	G	G

1. 24 ga with tie-rods in center
2. 22 ga with tie-rods in center
3. 22 ga with tie-rods in ends
4. 22 ga with tie-rods in center and ends
5. 20 ga with tie-rods in ends
6. 20 ga with tie-rods in center and ends
7. 18 ga with tie-rods in ends
8. 18 ga with tie-rods in center and ends

J. 18 ga with no reinforcement or 22 ga with tie-rods in center and ends

D. Pressure Class: 4” WG Pos. or Neg.

Material: Galvanized, G90 grade

Standard Joint: 55 ¾” (18 gauge – 24 gauge)

Seams: Longitudinal Pittsburgh seams for all ducts and fittings
All longitudinal seams sealed.

Joint Types: TDF flange and gasket.
No additional reinforcement unless noted.

Duct Reinforcing: ¾" EMT conduit & Condu-Lock,
Max spacing 30" on center.

DUCT GAUGE/REINFORCEMENT					
Duct Dimension	Duct Length				
	49" – 60"	37" – 48"	31" – 36"	25" – 30"	24" - Down
12" – Down	24	24	24	24	24
13" – 18"	24	24	24	24	24
19" – 22"	24	24	24	24	24
23" – 28"	22	24	24	24	24
29" – 30"	C	22	24	24	24
31" – 36"	E	C	22	22	24
37" – 42"	D	D	C	C	22
43" – 48"	D	D	C	C	C
49" – 54"	D	D	E	C	C
55" – 60"	D	D	E	C	C
61" – 72"	F	D	G	E	C
73" – 84"	\\\\\	F	G	E	E
85" – 96"	\\\\\	F	\\\\\	G	E
97" – Up	\\\\\	\\\\\	\\\\\	G	G

1. 24 ga with tie-rods in center
2. 22 ga with tie-rods in center
3. 22 ga with tie-rods in ends
4. 22 ga with tie-rods in center and ends
5. 20 ga with tie-rods in ends
6. 20 ga with tie-rods in center and ends
7. 18 ga with tie-rods in ends
8. 18 ga with tie-rods in center and ends

J. 18 ga with no reinforcement or 22 ga with tie-rods in center and ends

E. Pressure Class: 6" WG Pos. or Neg.

Material: Galvanized, G90 grade

Standard Joint: 55 ¾" (18 gauge – 24 gauge)

Seams: Longitudinal Pittsburgh seams for all ducts and fittings
All longitudinal seams sealed.

Joint Types: Through 18 ga: TDF flange and gasket.
16 ga: Manufactured Flange
No additional reinforcement unless noted.

Duct Reinforcing: ¾" EMT conduit & Condu-Lock,
Max spacing 30" on center.

DUCT GAUGE/REINFORCEMENT					
Duct Dimension	Duct Length				
	49" – 60"	37" – 48"	31" – 36"	25" – 30"	24" - Down
12" – Down	24	24	24	24	24
13" – 18"	22	24	24	24	24
19" – 20"	22	24	24	24	24
21" – 24"	22	22	24	24	24
25" – 26"	20	22	24	24	24
27" – 28"	20	C	22	22	24
29" – 30"	18	C	22	22	24
31" – 36"	18	20	C	22	24
37" – 42"	D	D	E	C	C
43" – 48"	F	D	D	C	C
49" – 54"	F	D	D	E	C
55" – 60"	F	D	G	G	C
61" – 72"	H	F	F	G	E
73" – 84"	\\\\\	\\\\\	\\\\\	G	G
85" – 96"	\\\\\	\\\\\	\\\\\	G	G
97" – Up	\\\\\	\\\\\	\\\\\	16	16

1. 24 ga with tie-rods in center

2. 22 ga with tie-rods in center
3. 22 ga with tie-rods in ends
4. 22 ga with tie-rods in center and ends
5. 20 ga with tie-rods in ends
6. 20 ga with tie-rods in center and ends
7. 18 ga with tie-rods in ends
8. 18 ga with tie-rods in center and ends

J. 18 ga with no reinforcement or 22 ga with tie-rods in center and ends

F. Pressure Class: 10” WG Pos. or Neg.

Material: Galvanized, G90 grade

Standard Joint: 55 ¾” (18 gauge – 24 gauge)

Seams: Longitudinal Pittsburgh seams for all ducts and fittings
All longitudinal seams sealed.

Joint Types: Through 18 ga: TDF flange and gasket.
16 ga: Manufactured Flange
No additional reinforcement unless noted.

Duct Reinforcing: ¾” EMT conduit & Condu-Lock,
Max spacing 30” on center.

DUCT GAUGE/REINFORCEMENT					
Duct Dimension	Duct Length				
	49” – 60”	37” – 48”	31” – 36”	25” – 30”	24” - Down
8” – Down	24	24	24	24	24
9” – 12”	22	24	24	24	24
13” - 18”	20	20	24	24	24
19” - 22”	18	20	22	22	24
23” – 26”	18	E	C	22	22
27” – 28”	G	18	C	C	22
29” – 30”	16	G	C	C	C
31” – 36”	16	G	C	C	C
37” – 42”	\\\\\	16	G	E	E
43” – 48”	\\\\\	\\\\\	G	G	E
49” – 54”	\\\\\	\\\\\	16	G	E

55” – 60”	\\\\\	\\\\\	16	G	E
61” – 72”	\\\\\	\\\\\	\\\\\	16	G
73” – 84”	\\\\\	\\\\\	\\\\\	\\\\\	16
85” – 96”	\\\\\	\\\\\	\\\\\	\\\\\	16
97” – Up	\\\\\	\\\\\	\\\\\	\\\\\	16

1. 24 ga with tie-rods in center
2. 22 ga with tie-rods in center
3. 22 ga with tie-rods in ends
4. 22 ga with tie-rods in center and ends
5. 20 ga with tie-rods in ends
6. 20 ga with tie-rods in center and ends
7. 18 ga with tie-rods in ends
8. 18 ga with tie-rods in center and ends
9. 18 ga with no reinforcement or 22 ga with tie-rods in center and ends

2.5 DOUBLE WALL DUCTWORK

A. Double Wall (Insulated) Ductwork: Fabricate double-wall (insulated) ductwork with an inner and outer shell and a 2" liner between. Dimensions indicated on internally insulated ducts are inside dimensions.

1. Thermal Conductivity (k-Value): 0.26 at 75 deg. F means temperature.
2. Outer Shell: Base outer-shell metal thickness is 18 gauge metal. Use the same metal thicknesses for uninsulated fittings as outer duct.
3. Insulation: 2" thick fibrous-glass insulation, (duct liner) unless otherwise indicated. Terminate insulation where internally insulate duct connects to single-wall duct or uninsulated components. Terminate insulation and reduce outer duct dimension to nominal single-wall size.
4. Perforated Inner Liner: Base inner shell metal thickness is 22 gauge metal.
5. This ductwork shall be installed on the first 20'-0" on all ducts connected to the air handler unit or more as indicated on the contract documents. Construct to medium pressure requirements as outlined herein.
6. Perforated Liner shall consist of 3/32 perforations spaced to provide 23% free area.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Contractor shall include allowances for structural, piping, and conduit interferences not evident during the bid phase or indicated on the drawings. Interferences are to be worked out during the shop drawing phase.

B. Contractor to take special care of shipping, handling and assembly of ductwork.

C. Provide offsets at interference locations and/or where changes in ceiling heights require such offsets; offsets shall be smooth as possible and without the need for hard elbows; offsets shall minimize the elbow/offset angle required which shall result in minimal static pressure gradients into the system.

D. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

E. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

F. All ductwork openings shall be covered, protected and sealed against contaminant migration into the airstream and shall be covered by plastic. Plastic to be removed upon continuation of work. Maintain integrity of protection as the work progresses.

G. Use 24 inch minimum length, straight sheet metal duct directly adjacent to inlets at terminal boxes.

H. Connect diffusers and grilles (exhaust and return) to low pressure ducts with 8 feet maximum length of straight run insulated flexible duct. Hold in place with strap or clamp. Flex duct shall be supported such that the installation is in kink-free manner. Use Thermaflex FlexFlow elbows at all air inlet and outlet connection to flex ducts.

I. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

J. Install Buckley fittings per manufacturer's instructions. Secure with sheet metal screws.

K. Where ductwork is exposed to weather, provide .060” thick EPDM membrane adhered to the ductwork.

L. All ductwork located within 20’ of the discharge and return air opening around air handling equipment shall be solid double wall with 22 gauge perforated inner liner, 18 gauge outer shell and 2” thick acoustic duct liner between the liner and shell. The inner duct shall be the pressure duct where the inner duct is solid wall.

3.2 DUCTWORK MATERIAL SCHEDULE

AIR SYSTEM	MATERIAL
Supply, Return, Relief and Intake	G90 Steel
General Exhaust	G90 Steel
First 20' of ductwork of discharge and return air opening around each air handling unit	G90, Double wall, 22 gauge inner, 18 gauge outer (see execution)
Shower/Locker Room Exhaust	Aluminum; liquid tight joints

3.3 DUCTWORK PRESSURE CLASSIFICATION

SYSTEM	CLASSIFICATION
Ductwork: Main return	Medium Pressure; 4 inch; Seal Class A
Ductwork: Equipment to terminal unit	Medium Pressure; 4 inch; Seal Class A
Ductwork: Terminal unit to air outlet	Low Pressure; 1 inch
Ductwork: Branch return and general exhaust	Low Pressure; 2 inch, Seal Class A
Ductwork: Fume hood exhaust	Medium Pressure; 4 inch, Seal Class A
Ductwork: General Exhaust <1”	Low Pressure, 1 inch
Ductwork: Within equipment room	Medium Pressure; 4 inch, Seal Class A

3.4 DUCTWORK LEAKAGE TESTING

A. The Contractor shall not insulate the systems until leakage tests have been performed and results accepted.

B. The Contractor shall, at the beginning of the work, construct, erect and leak test a representative sample of the duct construction to be used which is designed to operate at static pressures 3" wg and above. The sample specification shall be at least 25% of the entire system which shall include at least five transverse joints, two typical seams, an access door, typical branch connections, at least one elbow and two fire or fire/smoke dampers. All shafts/risers shall be leak tested prior to insulating and enclosing.

C. The pressure testing shall be performed in accordance with the SMACNA HVAC Air Duct Leakage Test Manual, latest edition.

D. The leakage amount shall not exceed the allotted amount for the pressure class or the allotted amount for that portion of this system, whichever is applicable.

DUCT CONSTRUCTION CLASS	RATE OF AIR LEAKAGE (C_L)
10" wg	3
6" wg	6
4" wg	6
3" wg	6

The Rate of Air Leakage (C_L) of the sample specimen shall be determined by the formula (C_L) = $F/P^{.65}$ where F is the measured leakage rate in cfm/100 sq. ft. duct area and P is the static pressure of the test.

E. If the sample specimen fails to meet the allotted rate of air leakage (C_L), the Contractor shall modify to bring it into compliance and shall retest it until the acceptable leakage level is demonstrated. Excessive buttering with duct sealant is prohibited.

F. Tests and necessary repair shall be completed prior to the installation of insulation and concealment of ductwork.

END OF SECTION 23 31 13

SECTION 23 33 10 - DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Volume control and shut off dampers

C. Fire dampers

D. Smoke dampers

E. Air turning vanes

F. Flexible duct connections

G. Duct access doors

H. Duct test holes

1.2 RELATED WORK

A. Division 23 – HVAC Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Ductwork

D. Division 23 Section "Fire Alarm" for duct-mounting fire and smoke detectors

E. Division 23 Section "HVAC Instrumentation and Controls" for electric and pneumatic damper actuators.

1.3 REFERENCES (LATEST EDITION)

A. AMCA 500-D – Laboratory Methods for Testing Dampers for Ratings

B. AMCA 511 – Certified Ratings Program for Air Control Devices

C. IBC – International Building Code

D. NFPA 90A – Installation of Air Conditioning and Ventilating Systems

E. NFPA 92A – Smoke Control Systems

F. NFPA 92B – Smoke Control Systems in Atria, Covered Malls and Large Areas

G. NFPA 101 – Life Safety Code

H. SMACNA – Duct Construction Standards

I. UL 33 – Heat Responsive Links for Fire-Protection Service

J. UL 555 – Standard for Safety: Fire Dampers

K. UL 555S – Standard for safety leakage characteristics for dampers in engineered smoke control systems

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 01 and 23, Common Work Results for HVAC.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Include rated capacities, outlet velocities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Motor ratings and electrical characteristics, plus motor and electrical accessories.
2. Material thickness and finishes, including color charts
3. Dampers, including housings, linkages, and operators.
4. Controllers and other controls.
5. Special fittings
6. Manual-volume damper installations
7. Motorized-control damper installations
8. Fire-damper, smoke-damper, and combination fire and smoke damper installations, including sleeves and duct-mounting access doors.
9. Wiring Diagrams: Power, signal, and control wiring.
10. Copies of UL Installation Instructions.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

D. Wiring Diagrams: Power, signal, and control wiring.

E. Design Calculation: Calculate requirements for seismic restraints.

F. All fan motors shall be non-overloading and selected per the discretion of the Engineer.

G. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.

H. Field quality-control test reports.

I. Operation and Maintenance Data: To include in emergency, operation, and maintenance manuals.

J. Structural steel fabrication and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings, roof hatches, duct through roof penetrations, expansion joints, etc.) Exact sizes and exact locations of openings are to be verified with the approved shop drawings issued for the installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. Sizes and locations indicated on Contract Drawings are diagrammatic and for information only. Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacturer and must be repaired, relocated, altered, replaced, re-installed or modified in any manner will be done to the satisfaction of the Owner with no additional cost to the Owner or design professional.

K. Submit the Installation, Operation and Maintenance Manual (IOM) and install thereto.

L. Manufacturer Seismic Qualification Certification: Submit certification that units of this section, accessories, and components will withstand seismic forces defined in Division 23, Section "Vibration Isolation and Seismic Restraints for HVAC Components." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

M. Provide shop drawings for the following:

1. Fire dampers
2. Smoke dampers
3. Air turning vanes
4. Volume dampers
5. Flexible duct connections
6. Duct access doors
7. Duct test holes

N. Submit air pressure drop calculations for each smoke damper and combination fire/smoke damper. Calculations shall include system effects due to elbows, air velocities, non-optimal straight duct lengths, transitions, obstructions and other applicable effects fore/aft of each device. Dampers shall be enlarged in size and transitions be provided as required to system effects in order to provide the actual air pressure drops at 1800 FPM as tested and measured in the factory. The maximum pressure drop shall be 0.25" wg.

1.5 COORDINATION

A. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

B. Coordinate size and location of structural-steel support members.

C. Coordinate installation o ductwork accessories with actual location.

1.6 QUALITY ASSURANCE

A. Comply with NFPA 90A, 92A, 92B and 101 and all applicable building codes.

1.7 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver. Store, store, protect and handle fans and accessories according to Div. 01 and 23 requirements, comply with manufacturer’s instructions.

B. Delivery: Deliver materials to site in manufacturer’s original, unopened containers and packaging, with labels clearly indicating manufacturer, material, products included, and location of installation

C. Storage: Store materials in a dry area indoor, protected from damage, and in accordance with manufacturer’s instructions. For long term storage follow manufacturer's Installation, Operations, and Maintenance Manual

D. Handling: Handle and lift ductwork accessories in accordance with the manufacturer’s instructions. Protect materials and finishes during handling and installation to prevent damage. Follow all safety warnings posted by the manufacturer.

E. Protect motors, shafts, and bearings from weather and construction dust. Provide sealed housings to prevent debris from entering assembly. Store units off-site until surfaces are ready for immediate installation.

F. Comply with Section 018113.13, Sustainable Design Requirements for LEED. While complete compliance with Section 018113.13 is mandatory, specific requirements related to LEED Indoor Environmental Quality Credit 3.1 (Construction IAQ Management Plan - During Construction) shall be referenced under 1.5, Part 2, Part 3, and the Project's Construction IAQ Management Plan — provide submittals in the form of photographs documenting construction and pre-occupancy phase moisture protection for absorptive materials. Additionally, all permanently installed air handling units are not to be operated until all finishes are installed and the building is deemed ready for occupancy by the Architect/Engineer. Therefore, all return grilles and supply diffusers shall be covered with plastic to prevent contamination of ductwork and coils; documentation in the form of photographs shall ensure the implementation of said protective measures. Installing filtration media at the return grilles associated with permanently installed HVAC units shall not be considered an acceptable approach to credit achievement.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10% of amount installed.

1.9 WARRANTY

A. One year warranty on parts and labor from date of final acceptance.

1.10 MAINTENANCE MANUALS

A. Submit and refer to Manufacturer's Installation, Operation and Maintenance Manual (IOM), to find maintenance procedures.

PART 2 - PRODUCTS

2.1 Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise, or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding**.

2.2 ACCEPTABLE MANUFACTURERS – VOLUME CONTROL AND SHUT OFF DAMPERS

A. Ruskin

B. Louvers and Dampers

C. Greenheck

2.3 VOLUME CONTROL AND SHUT OFF DAMPERS

A. Control Dampers: AMCA Standard 500-D tested and rated. Provide dampers with parallel blades for 2-position control, or opposed blades for modulating control. Construct blades of 16 gauge steel; provide heavy-duty molded self-lubricating nylon bearings, 1/2 inch hex steel axles spaced on 9" centers. Construct frame of 5 inch x 1 inch x 16 gauge steel channel with linkage concealed within the jamb. Finish is to be galvanized. For dampers located in ductwork with air velocities greater than 1500 FPM, dampers shall have airfoil blades. Provide frames to accept Ductmate joints where applicable transverse joints are provided. Provide a 2" standoff bracket and locking quadrant manual operator. Dampers for moisture laden airstreams or corrosive environments shall be type 304 stainless steel construction including bearings. Provide sleeve and security bars where required.

B. Provide positive-locking air volume damper. Provide quadrant (damper handle) which has a spring-loaded locking mechanism which ensures that the handle’s position remains locked where it is set. A wingnut lockdown is not acceptable. Field assembled damper hardware into duct and fittings. Snap-In Bearings into 3 inch holes on each side of the duct or fitting, holding the round continuous-rod damper blade in position and passing the rod through the pre-stamped channel in the blade and the bearings. Dampers handle on the outside of the fitting or duct. Damper adjustments can be made by hand—without the need for any tool. The Positive-Locking Air Volume Damper consists of a locking damper handle (or quadrant), two 3 inch bearings, a rod and a round damper blade. All the components shall adhere to the relevant UL requirements, Plenum ratings and SMACNA standards for manual dampers; and are in compliance with NFPA 90A & 90B Standard for the Installation of Air-Conditioning and Ventilating Systems. All non-metallic components are made of fame retardant polymer with a free rating of 5VA as specified in UL 1995 Standards Code for Heating & Cooling. The positive locking damper handle consists of a bracket, a handle, a thumb trigger, a spring and a retaining ring. The bracket is made of cold rolled steel in conformance with ASTM A1008, 18 gauge nominal thickness 0.0478, tolerance range 0.0438–0.0518. The Handle & Thumb Trigger is made of Polyamide 66 (PA66), flame retardant, glass-reinforced polymer in conformance with CSA-C22.2 No. 238 UL 1995. Stainless steel 302-OP 0.25 wire Compression Spring, 0.026 free length; 7 inch; ten coils, closed, not ground. Carbon Spring Steel with Zink Bright Plating Retaining Ring, C-SCALE Rockwell Hardness 47–51, Country of origin: USA. Snap-in Bearings (11 inch) (B Long) for use with inside-insulated, (lined), duct and fittings. B-Longs are recommended for all pressure class applications. B-Snaps are recommended for low or medium pressure systems. Clip-on Bearings snap into a 3 inch hole with an E-Clip securing the bearing from the opposite side. Continuous Rod Damper Blades - Galvanized ASTM A553 LFO G90, 20 and 22 gauge; designed with additional radial reinforcement throughout the disc which effectively equals the strength of 18 gauge material. Available in 4–16 inch diameter. A 3 inch full length bar fits through the formed channel in the center of each damper blade. Basis of Design: Rossi Positive-Locking Air Volume Damper.

C. Intake and Relief Air Dampers: Provide dampers with opposed blade except gravity relief air dampers shall be parallel blade. Frames and blades shall be of aluminum construction. Blades shall be of the airfoil design. Axle shall be 1/2 inch hex and fitted into nylon bearings. Provide ball bearings on gravity relief dampers. Blades shall be provided with neoprene end and jamb seals for a tight shut off. Construct frame of 5 inch x 1 inch x .125 minimum wall thickness. Provide frames to accept Ductmate joints where applicable transverse joints are provided.

2.4 ACCEPTABLE MANUFACTURERS – FIRE AND SMOKE DAMPERS

A. Ruskin

B. Greenheck (Basis of Design)

C. Reviewed equivalent.

2.5 FIRE DAMPERS

A. General: UL Listed per UL Standard 555, dynamic type, 1-1/2 hour rated for assembles less than 3 hour rating, 3 hour rated for assemblies 3 hour or greater rating, refer to contract documents for wall type, rating and construction.

B. Type: Use Type C curtain damper for low pressure duct system sizes for maximum single assembly of 31" x 31" rectangular, 31" diameter round and 46" x 31" oval. For duct sizes larger, use multi-blade type fire dampers. Use multi-blade type for medium pressure duct systems (upstream of VAV/CV boxes and Phoenix valves).

C. Fire Closure Temperature: Each fire damper shall be equipped with a fusible link rated to close the damper when temperature at the damper reaches 165° F.

D. Differential Pressure: Dampers shall have a minimum UL 555 differential pressure of 4" wg.

E. Velocity: Curtain dampers and low pressure multi-blade dampers have minimum UL velocity rating of 2000 fpm. Medium pressure system multi-blade dampers shall have minimum UL velocity rating of 3000 fpm.

1. Curtain Fire Damper Construction: Galvanized steel in gauges required by manufacturer's UL Listing. Provide frame, sleeve, retaining angles, blades, links and duct transition connection (Type C, Type CO, Type CR) for each damper. Dampers for moisture laden airstreams or corrosive environments shall be type 304 stainless steel construction.

F. Multi-blade Damper Construction

1. Frame: Galvanized steel formed into 5" x 1" structural hat channel. Top and bottom frame members on dampers less than 17" high shall be low profile design to maximize free area. Frame to be 4-piece construction with minimum 1-1/2" integral overlapping gusset reinforcement in each corner to assure square corners and provide maximum resistance to racking.
2. Blades: 16 gauge galvanized steel with 1" each deep-vee grooves along the blade with each blade being symmetrical. Provide airfoil blades for medium pressure systems.
3. Blade Stops: Maximum 1/2" around the damper openings.
4. Jamb Seals: Flexible stainless steel compression type.
5. Linkage: Concealed in jamb.
6. Axles: Minimum 1/2" diameter plated steel.
7. Bearings: Bronze sleeve type in polished extruded holes.
8. Dampers for moisture laden airstreams or corrosive environments shall be type 304 stainless steel construction including bearings.
9. Provide sealed sleeves with breakaway Ductmate flanges, retaining angles, links and duct transitions for each damper.

G. Provide security bars where required, refer to contract documents. Provide manual quadrant actuator where required for balancing, consult with Engineer.

H. The minimum size damper shall be 12" x 12", provide transitions for duct sizes smaller than 144 square inches.

I. Application (Basis of Design)

1. Low pressure 1-1/2 hour rated: Greenheck DFD-150
2. Low pressure 3 hour rated: Greenheck DFD-350
3. Medium pressure 1-1/2 hour rated: Greenheck DFD-210 (with volume damper accessory) and Greenheck DFDTF-210.

2.6 SMOKE DAMPERS

A. General: UL listed per UL Standard 555S, Class 1 leakage rate.

B. Elevated operational temperature: 350° F

C. Differential pressure = 4" wg per UL 555 S.

D. Velocity: Low pressure systems shall have a UL 555S rating of 2000 fpm; medium pressure shall have a UL 555S rating of 3000 fpm. Medium pressure systems are defined as ductwork upstream of VAV/CV boxes and Phoenix valves.

E. Dampers for moisture laden airstreams or corrosive environments shall be type 304 stainless steel construction including bearings.

F. Frame: 16 gauge galvanized steel formed into 5" x 1" structural hat channel, low profile design, 4 piece construction with minimum 1-1/2" integral overlapping gusset reinforcements in each corner to assure square corners and maximum resistance to racking.

G. Blades: 16 gauge galvanized steel, variable symmetrical, 3-vee blades for low pressure systems, double skin airfoil for medium pressure systems.

H. Blade Stops: Maximum 1/2" to maximize available free area.

I. Blade Seals: Extruded silicone rubber permanently bonded to the blade.

J. Jamb Seals: Flexible stainless steel compression type.

K. Linkage: Concealed in jamb.

L. Axles: Minimum 1/2" diameter plated steel.

M. Bearings: Sintered bronze type rotating in polished extruded holes in the frame.

N. Provide sealed sleeves with breakaway Ductmate flanges and retaining angles sized per UL Listing.

O. Actuator: Electric, 24 VAC 1 phase, modulating; coordinate with electrical documents. Coordinate with contractor regarding internal or external mounting of actuator with accessibility and maintenance requirements. Fail open.

P. Accessories: For each damper, provide the following:

1. Greenheck OCI – open/closed indicating DPDT switch.
2. Transitions to round and oval ductwork as required.
3. Fail open.
4. Greenheck GTS-3 test panel with momentary test switch with closed and open indicating LED's.
5. Sleeve Joints: Where required shall be Ductmate type, else use slip and drive; coordinate as required.
6. Access door.
7. Security Bars: Where required, refer to plans.
8. Sleeve Joints: Ductmate type

Q. The minimum damper size shall be 12" x 12", provide transitions for duct sizes smaller than 144 square inches.

R. Application (Basis of Design):

1. Low Pressure: Greenheck SMD-201
2. Medium Pressure: Greenheck SMD-301

2.7 ACCEPTABLE MANUFACTURERS – AIR TURNING VANES

A. Aero Dyne HEP as Basis of Design

2.8 AIR TURNING VANES

A. Multi-blade device with 3" radius blades aligned on 2.4" centers; steel or aluminum construction with set and lockable blades, mounting straps. Performance shall be 0.027" wg pressure drop at 1000 FPM air velocity; 0.105" wg static pressure drop at 2000 FPM air velocity and 0.24" wg static pressure drop at maximum air velocity of 3000 FPM.

2.9 ACCEPTABLE MANUFACTURERS – FLEXIBLE DUCT CONNECTIONS

A. Ventfabrics (Basis of Design)

2.10 FLEXIBLE DUCT CONNECTIONS

A. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

B. Metal-Edged Connectors: Factory fabricated with a fabric strip 6" wide attached to two strips of 3" wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum or stainless steel sheets. Select metal compatible with ducts.

C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene. Model Ventglas.

1. Minimum Weight: 30 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 20 to plus 200 degrees F.
4. Service Pressure: Rated to +/- 10" wg.

D. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and Ozone. Model Ventlon.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus to plus 275 degrees F.
4. Service Pressure: Rated to +/- 10" wg.

E. High-Temperature System, Flexible Connectors: glass fabric coated with silicone rubber. Model Ventsil.

1. Minimum Weight: 16 oz./sq. yd.
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 25 to plus 500 degrees F.
4. Service Pressure: Rated to +/- 8" wg.

F. High-Corrosive Environment System, Flexible Connectors: Glass fabric with chemical resistant coating. Model Ventel.

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 degrees F.
4. Service Pressure: Rated to +/- 8" wg.

2.11 ACCEPTABLE MANUFACTURERS – DUCT ACCESS DOORS

A. Duro Dyne

B. Ruskin

C. Ductmate

D. Air Balance

2.12 DUCT ACCESS DOORS

A. Fabricate in accordance with SMACNA Duct Construction Standards and as indicated.

B. Review locations prior to fabrication.

C. Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.

D. Access doors smaller than 12 inches square may be secured with sash locks.

E. Provide two hinges and two sash locks for sizes up to 18 inches square, three hinges and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide an additional hinge for larger sizes.

F. Access doors with sheet metal screw fasteners are not acceptable.

G. The access openings shall not reduce the fire-resistance rating of the assembly. Access points shall be permanently identified on the exterior by a label having letters not less than 0.5 inch in height reading: SMOKE DAMPER or FIRE DAMPER.

2.13 DUCT TEST HOLES

A. Permanent test holes shall be factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings with screw cap. Provide extended neck fittings to clear 2" insulation thickness.

B. Manufacturer – Ventlok 699-2

2.14 SOURCE QUALITY CONTROL

A. Factory Tests: Factory cycle damper and actuator assemblies to assure proper operation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions.

B. Inspect areas to receive dampers. Notify the Engineer of conditions that would adversely affect the installation or subsequent utilization of the dampers. Do not proceed with installation until unsatisfactory conditions are corrected.

C. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts and branch ducts and as required for air balancing; whether indicated on the contract drawings or not.

D. Provide fire and smoke dampers and smoke dampers at locations required whether indicated on the contract drawings or not, where ducts and outlets pass through fire, smoke and fire/smoke rated components. Include locations as required by code authorities to isolate the air handling equipment. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings, and hinges. Install per UL and NFPA requirements.

E. Locate normal/alarm remote test indicating panels on adjacent walls for duct smoke detectors; mount 48" AFF level with light switches.

F. For fire and smoke dampers; install PVC cleats on the Ductmate type joints; do not install the corner clip bolts. Use slip joints for dampers provided without Ductmate joints. For round and oval ductwork connecting to fire dampers, use galvanized slip joints.

G. Install fire and smoke dampers per the manufacturer's UL approved installation instructions. Provide a frame system in the wall to support the sleeve; construct according to the manufacturer’s installation instructions and per code requirements. Installations shall be approved by the local code bodies having jurisdiction. Install dampers square and free from racking with blades running horizontally. Do not compress or stretch damper frame into duct or opening. Handle damper using sleeve or frame. Do not lift damper using blades, actuator, or jackshaft. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

H. All fire, smoke and ceiling dampers shall be operated and tested by Contractor prior to occupancy of a building to determine that they function properly in accordance with NFPA 90A. Provide a compliance report to Engineer and Owner for approval a minimum of 14 days prior to final project closeout.

I. Provide minimum 3 equivalent straight duct diameters upstream and downstream of smoke dampers. If more space is available, then use the maximum allowable straight duct lengths.

J. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment.

K. Provide duct access doors for inspection and cleaning at filters, coils, fans, automatic dampers, fire dampers, combination fire/smoke dampers, smoke dampers, duct smoke detectors and elsewhere as indicated. Provide minimum 18 x 18 inch size unless duct size will not allow; else use maximum available size. Provide duct access doors for steam grid humidifiers.

L. Provide duct test holes in the supply and return main ducts in straight sections near air handling units before branch take-offs. In addition, provide test holes in exhaust ducts at exhaust fans. Use judgement in locating test holes to improve CFM readings. Locate test holes a maximum of 9 inches on center. Indicate locations on ductwork shop drawings. Test holes shall clear insulation.

M. 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.

N. Provide 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. Dampers for moisture laden airstreams or corrosive environments shall be type 304 stainless steel construction including bearings.

O. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

P. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

1. On both sides of duct coils.
2. Downstream from volume dampers, turning vanes, and equipment.
3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
5. On sides of ducts where adequate clearance is available.

Q. Install the following sizes for duct-mounting, rectangular access doors:

1. One-Hand or Inspection Access: 8 by 5 inches
2. Two-Hand Access: 12 by 6 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

R. Install the following sizes for duct-mounting, round access doors:

1. One-Hand or Inspection Access: 8 inches in diameter
2. Two-Hand Access: 10 inches in diameter
3. Head and Hand Access: 12 inches in diameter
4. Head and Shoulders Access: 18 inches in diameter
5. Body Access: 24 inches in diameter

S. Install the following sizes for duct-mounting, pressure relief access doors:

1. One-Hand or Inspection Access: 7 inches in diameter
2. Two-Hand Access: 10 inches in diameter
3. Head and Hand Access: 13 inches in diameter
4. Head and Shoulders Access: 19 inches in diameter

T. Label access doors according to Division 23 Section "Identification for HVAC."

U. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

V. Dampers must be accessible to allow inspection, adjustment, and replacement of components. The sheet metal contractor shall furnish any access doors in ductwork or plenums required to provide this access. The general contractor shall furnish any access doors required in walls, ceilings or other general building construction.

W. Install dampers square and free from racking.

X. The installing contractor shall provide and install bracing for multiple section assemblies to support assembly weight and to hold against system pressure.

Y. Do not compress or stretch the damper frame into the duct or opening.

Z. Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Install support mullions as reinforcement between assemblies as required.

AA. Handle dampers using the frame or sleeve. Do not lift or move dampers using blades, actuator or jackshaft.

BB. Install connections to electric, actuators as specified in Division 23.

CC. Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Install support mullions as reinforcement between assemblies as required.

DD. Primary elements shall be installed in strict accordance with the manufacturer's published requirements, and with ASME guidelines effecting non-standard approach condition. These elements serve as the primary signals for the airflow systems; therefore; it shall be the responsibility of the Contractor to verify and install, to assure that accurate primary signals are obtained.

EE. Coordinate with other work, including ductwork, electrical, mechanical, and automatic temperature controls, as necessary to interface the installation of the airflow control systems with other work.

FF. Provide an identification label to be placed on each unit casing listing model number, size, area, and specified airflow capacity.

GG. Provide an identification label to be placed on each primary flow element showing airflow direction and listing the model number, system served, size and identifying tag number.

HH. Provide an identification label to be placed on each airflow indicating transducer listing the model number flow elements served, full scale value, and identifying tag number.

3.2 START UP SERVICE AND GUARANTEE

A. Provide Factory Authorized startup service. A factory certified representative shall visit the job site after the successful contractor completes installation. The startup service will require inspection of each device; placement location, wiring and operation. A written report of the findings from the start up service shall be provided to the mechanical engineer for review and approval.

B. Upon approval by the mechanical engineer, each device shall be provided with a 12 month “on-site” warranty for defective equipment and shall also be provided with a standard limited parts warranty for total 36 month coverage from date of shipment.

3.3 FIELD QUALITY CONTROL

A. Provide factory authorized personnel to field quality control. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

B. Perform the following field tests and inspections and prepare test reports:

1. Verify that the installation complies with the manufacturer’s instruction and provides a workable system for the owner, installed per the design intent anf that is code compliant to authorities having jurisdiction.

2. Verify that unit is secure on mountings and supporting devices and that connection to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Adjust damper linkages for proper damper operation.
5. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
7. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
8. Shut unit down and reconnect automatic temperature-control operators.
9. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Provide factory authorized personnel to provide adjustment. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

E. Adjust damper linkages for proper damper operation.

F. Adjust belt tension.

G. Refer to Division 23 Section "Testing, Adjusting, and Balance for HVAC" for testing, adjusting, and balancing procedures.

H. Replace fan and motor pulleys as required to achieve design airflow.

I. Lubricate bearings.

3.4 MANUFACTURER'S FIELD SERVICES

A. Provide factory authorized personnel to initial start-up, check out and shut-down. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

B. Prior to startup, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections and complete pre-startup checklists. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, engage a factory-authorized service representative to start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. The FMCS vendor shall provide programming of the unit for optimum start/stop, morning cool-down cycle, morning warm- up cycle, timed override, date (daily, weekly, monthly, holiday, etc) occupied and unoccupied periods as well as all programming required for the sequence of operation.

3.5 TRAINING

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

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 01 and Division 23.

B. Schedule training with Owner, through Architect, with at least seven days advance notice.

END OF SECTION 23 33 10

SECTION 23 34 23 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Roof exhausters

B. Ceiling and cabinet exhaust fans

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Common Motor Requirements for HVAC Equipment

D. Division 23 – Ductwork Accessories

E. Division 23 – Vibration Isolation and Seismic Restraints

F. Division 23 – Sequence of Operation

G. Division 23 – Facilities Management and Control System

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 REFERENCES

A. Air Movement and Control Association Inc. (AMCA):

1. 99 - Standards Handbook
2. 200 - Publication, Air Systems
3. 201-90 - Publication, Fans and Systems
4. 202-88 - Publication, Troubleshooting
5. 203-90 - Publication, Field Performance Measurement of Fan Systems
6. 211-05 - Publication, Certified Ratings Program – Product Rating Manual for Fan Air Performance
7. 300-96 - Standard Reverberant Room Method for Sound Testing of Fans

8. 311-05 - Publication Certified Ratings Program – Product Rating Manual for Fan Sound Performance
9. 99-0401-86 - Classification for Spark Resistant Construction
10. 99-2408-69 - Operating Limits for Centrifugal Fans

B. Air Movement and Control Association Inc. (AMCA), American National Standards Institute (ANSI):

1. 204-05 - Standard Balance Quality and Vibration Levels for Fans
2. 210-99 - Standard Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

C. American National Standards Institute (ANSI):

1. 11-r1999 - Method of Evaluating Load Ratings of Bearings

D. American Society of Civil Engineers (ASCE):

1. 7-02 - Minimum Design Loads for Building and Other Structures

E. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):

1. Chapter 45 - 2003 Handbook, HVAC Applications
2. Chapter 7 - 2001 Fundamentals handbook, Sound-Vibration
3. Chapter 32 - 2001 Fundamentals handbook, Duct Design
4. Chapter 18 - 1992 HVAC System and Equipment handbook, Fans

F. American Society for Testing and Materials (ASTM):

1. E330-02 - Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylight and Curtain Walls by Uniform Static Air Pressure Difference

G. National Fire Protection Association (NFPA)

1. 70 - National Electrical Code
2. 90A-02 - Standard for the Installation of Air-Conditioning and Ventilating Systems
3. 92A-06 - Recommend Practice for Smoke-Control System
4. 92B-05 - Standard for Smoke Management System in Malls, Atria, and Large Areas
5. 96-04 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

H. Occupational Safety and Health Administration (OSHA):

1. 1910.212 - General requirements for Machine Guarding
2. 1910.219 - General requirements for guarding safe use of mechanical power transmission apparatus
3. 1926.300 - General requirements for safe operation and maintenance of hand and power tools

I. Underwriters Laboratories (UL):

1. 507 - Electric Fans
2. 555 - Fire Dampers
3. 555S - Smoke Dampers
4. 705 - Standard Power Ventilators
5. 762 - Standard Power Roof Ventilators for Restaurant Exhaust Appliances
6. 793 - Snow Load

1.5 QUALITY ASSURANCE

A. Performance ratings: Conform to AMCA standard 211 and 311. Fans must be tested in accordance with ANSI/AMCA Standard 210-99 and AMCA Standard 300-96 in an AMCA accredited laboratory. Fans shall be certified to bear the AMCA label for air and sound performance seal

B. Classification for Spark Resistant Construction Conform to AMCA 99

C. Each fan shall be given a balancing analysis which is applied to wheels at the outside radius. The maximum allowable static and dynamic imbalance is 0.05 ounces (Balance grade of G6.3)

D. Comply with the National Electrical Manufacturers Association (NEMA), standards for motors and electrical accessories

E. The High Wind models shall be analyzed and stamped by a state license P.E. to the ASCE 7-02 Standard which meets the IBC, Florida and Miami-Dade codes

F. Each High Wind model is subject to be certified by a third party to the ASTM E330 Static Pressure Difference Standard

G. All High Wind models shall be analyzed using Computational Fluid Dynamics (CFD). The CFD simulates the flow of high speed (150MPH) winds over the surface of objects

H. The Finite Element Analysis (FEA) is the results from the CFD and it can accurately predict the stress, strain, and deflection resulting from high wind loads

1.6 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 01 and 23, Common Work Results for HVAC.

B. Product Data: Include rated capacities, outlet velocities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts

5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers and other controls.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Design Calculation: Calculate requirements for selecting vibration isolators and seismic restraints.

D. Provide fan curves with specified operating point clearly plotted. Fans/motors are selected for additional CFM and ESP from scheduled; fans shall meet Engineer's requirements. All fan motors shall be non-overloading and selected per the discretion of the Engineer.

E. Submit sound power levels for both fan inlet and outlet at rated capacity and acoustical treatment as one package.

F. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

I. Submit and comply with the Manufacturer’s Installation Manuals.

J. Structural steel fabrication and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings, roof hatches, duct through roof penetrations, expansion joints, etc.) Exact sizes and exact locations of openings are to be verified with the approved shop drawings issued for the installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. Sizes and locations indicated on Contract Drawings are diagrammatic and for information only. Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacturer and must be repaired, relocated, altered, replaced, re-installed or modified in any manner will be done to the satisfaction of the Owner with no additional cost to the Owner or design professional.

K. Manufacturer Seismic Qualification Certification: Submit certification that units of this section, accessories, and components will withstand seismic forces defined in Division 23, Section "Vibration Isolation and Seismic Restraints for HVAC Components." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 23 – Common Work Results for HVAC and requirements of Division 01.

B. Include instructions for lubrication, installation, motor and drive replacement, spare parts list and wiring diagrams.

C. Refer to Manufacturer's Installation, Operation and Maintenance Manual (IOM), to find maintenance procedures.

1.8 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver. Store, protect and handle fans and accessories according to Div. 01 and 23 requirements, comply with manufacturer’s instructions.

B. Delivery: Deliver materials to site in manufacturer’s original, unopened containers and packaging, with labels clearly indicating manufacturer, material, products included, and location of installation

C. Storage: Store materials in a dry area indoor, protected from damage, and in accordance with manufacturer’s instructions. For long term storage follow manufacturer's Installation, Operations, and Maintenance Manual

D. Handling: Handle and lift fans in accordance with the manufacturer’s instructions. Protect materials and finishes during handling and installation to prevent damage. Follow all safety warnings posted by the manufacturer.

E. Protect motors, shafts, and bearings from weather and construction dust. Provide sealed housings to prevent debris from entering assembly. Store units off-site until surfaces are ready for immediate installation.

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.10 WARRANTY

A. One year warranty on parts and labor from date of final acceptance.

1.11 SOUND CRITERA

A. All fans shall be selected to result in sound power levels (and without and objectionable tone to the occupant) within occupied spaces per ASHRAE sound criteria guidelines and LEED sound criteria guidelines as to gain the required LEED acoustics point. The Contractor shall work with the vendor prior to bid to accomplish this. Any work required due to the increase of fan size, equipment change from direct drive to belt drive, any sheave changes, any addition of VFD's, any addition of sound attenuators, any increase in motor HP size, any addition of ductwork size, any addition of needed internal acoustic lining, and addition of vibration isolators and seismic restraints, any addition of control sequence changes, software and programming, any increase in duct gauge to lessen breakout noise from the duct, any ductwork configuration or routing changes, any addition of electrical feeder size increase of breaker increases shall be conveyed to the Architect/Engineer prior to bid and prior to the last available date for addendum with a reasonable amount of time for the A/E to prepare the addendum memorandum. At the award of bid, the Contractor shall make good of such as needed to comply with this contract requirement.

1.12 MAINTENANCE

A. Submit and refer to the Manufacturer's Installation, Operation and Maintenance Manual (IOM), to find maintenance procedures.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Penn Barry

B. Loren Cook

C. Greenheck (Basis of Design)

2.2 GENERAL – ALL FANS

A. Fans used shall not decrease motor size, increase noise level, or increase tip speed by more than 10 percent, or increase inlet air velocity by more than 20 percent, from specified criteria. Fans shall be capable of accommodating static pressure variations of plus or minus 10 percent.

B. Base performance on site elevation conditions.

C. Statically and dynamically balance fans to eliminate vibration or noise transmission to occupied areas.

D. Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise levels or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding**.

2.3 ROOF AND WALL EXHAUST FANS

A. General: Centrifugal fan, V-belt or direct driven as scheduled, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 16 gage aluminum birdscreen; square base to suit roof curb with continuous curb gaskets; secured with cadmium plated bolts and screws. Motor shall be NEMA rated, wired and fused as per NEC and premium efficiency type. Motors that are VFD driven shall have shaft grounding.

B. Roof Curb: 18 inch high; double shell galvanized steel with continuously welded seams, built-in raised cant strip, curb bottom; factory installed 2 x 4 inch nailer strip (fireproof); and internal insulation.

C. Disconnect Switch: Factory wired, non-fusible, NEC compliant; mounted in or on fan housing wired to motor. For disconnect switch mounted on fan housing; provide NEMA 3R, lockable type.

D. Motorized Damper: 24 volt motor activated, aluminum multiple blade construction, felt edged, nylon bearings and end switch control to open damper prior to starting fan; fans for kitchen hoods shall not have dampers. Refer to 23 05 00 for control wiring. For ducts to fans that are less than 12" x 12"; damper to be gravity type.

E. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

F. Roof Mounted Upblast Exhaust Fans: A leakproof fan housing shall be constructed with a one-piece windband with an integral rolled bead for added strength.

2.4 CEILING EXHAUST FANS

A. Direct driven with galvanized steel housing; plastic ceiling grille, resilient mounted motor, gravity backdraft damper in discharge; variable speed motor; and variable speed controller mounted on fan, hanging brackets with rubber isolators, 60 second delay relay to let fan run after lights are turned off, round duct connection. Provide fan/light combinations as indicated on the drawings. Provide wall discharge cap. Provide soffit discharge grille with incoming elbow.

PART 3 - EXECUTION

3.1 GENERAL

A. Installing contractor shall install unit, including field installed components, in accordance with Installation, Operation and Maintenance manual instructions.

B. Any rigging devices (cranes, scaffolds) required shall be provided by the installing (Mechanical) Contractor.

3.2 EXAMINATION

A. Verify that roof, structure and floor is ready to receive work and opening dimensions are as illustrated by the manufacturer.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure roof exhausters with corrosion resistant lag screws to roof curb.

C. Install ceiling, cabinet and return fans on vibration isolators, refer to Division 23.

D. Provide frame for suspended installation, complete with all necessary beam clamps and hardware.

E. Coordinate roof openings with General Contractor.

F. Set units on roofcurbs with vibration isolation where not installed on dunnage. Turn over roofcurbs to the General Contractor for installation and roofing/flashing.

G. Check unit safeties and interlocks with fire alarm system.

H. Check unit operation for compliance with the sequence of operation.

I. Provide flexible connections on ductwork systems connected to each rooftop unit.

J. Ductwork penetrations through the roof shall be sealed with acoustical fill and acoustical grade caulk in order to eliminate gaps and resulting noise paths.

K. Provide sheave/belt changes as required for final air volume delivery as determined by the testing and balancing firm.

L. Provide two spare belts per fan.

M. Install power ventilators level and plumb.

N. Install units with clearances for service and maintenance.

O. Label units according to requirements specified in Division 23.

P. Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

Q. Install fans on isolator base and flexible electrical leads. Refer to Division 23.

R. Install flexible connections specified in Division 23 between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

S. Provide sheaves required for final air balance.

T. Provide safety screen where inlet or outlet is exposed.

U. Check and adjust wheel overlap.

V. Check belt alignment and adjust as required.

W. Check belt tension and adjust as required.

X. Locate panels for multipurpose fans where indicated on plans or directed by Engineer. Panel location shall have 36” clearance in front per NEC. Field wire from panel to motor including control voltage to dampers. Run all wiring in conduit.

3.4 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23.

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Connect wiring according to Division 26 Section "Wires and Cables".

3.5 FIELD QUALITY CONTROL

A. Provide factory authorized personnel to field quality control. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

B. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connection to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.
4. 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.
5. Adjust belt tension.
6. Align sheaves.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
11. Shut unit down and reconnect automatic temperature-control operators.
12. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 ADJUSTING

A. Provide factory authorized personnel to provide adjustment. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

B. Adjust damper linkages for proper damper operation.

C. Adjust belt tension.

D. Refer to Division 23 Section "Testing, Adjusting, and Balance for HVAC" for testing, adjusting, and balancing procedures.

E. Replace fan and motor pulleys as required to achieve design airflow.

F. Lubricate bearings.

3.7 MANUFACTURER'S FIELD SERVICES

A. Provide factory authorized personnel to initial start-up, check out and shut-down. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

B. Prior to startup, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections and complete pre-startup checklists. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, engage a factory-authorized service representative to start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. The FMCS vendor shall provide programming of the unit for optimum start/stop, morning cool-down cycle, morning warm- up cycle, timed override, date (daily, weekly, monthly, holiday, etc) occupied and unoccupied periods as well as all programming required for the sequence of operation.

3.8 TRAINING

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

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 01 and Division 23.

B. Schedule training with Owner, through Architect, with at least seven days advance notice.

END OF SECTION 23 34 23

SECTION 23 72 19 - ENERGY RECOVERY VENTILATORS

PART 1 - GENERAL

1.1 PRODUCT SPECIFICATION

A. Energy Recovery Ventilator (ERV) shall be a packaged unit as manufactured by RenewAire and shall transfer both heat and humidity using static plate core technology.

1.2 QUALITY ASSURANCE

A. 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 manufacture'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.

B. 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 NFPA 90A 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.

C. Unit shall be listed under UL 1812 Standard for Ducted Air to Air Heat Exchangers. Some exceptions to UL Listing may apply.

D. 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 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 years from the date of purchase.

1.3 PERFORMANCE

A. 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.

B. 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. No condensate drains will be allowed.

C. Continuous Ventilation: Unit shall have the capacity to operate continuously without the need for bypass, recirculation, pre-heaters or defrost cycles under normal operating conditions.

D. Positive Airstream Separation: Water vapor transfer shall be through molecular transport by hydroscopic resin and shall not be accomplished by "porous plate" mechanisms. Exhaust and fresh airstreams shall travel at all times in separate passages, and airstreams shall not mix.

E. Laminar Flow: Airflow through the ERV core shall be laminar over the products entire operating airflow range, avoiding deposition of particulates on the interior of the energy exchange plate material.

PART 2 - PRODUCTS

2.1 CONSTRUCTION

A. The energy recovery component shall be of fixed-plate cross-flow construction, with no moving parts.

B. No condensate drain pans or drains shall be allowed and unit shall be capable of operating in both winter and summer conditions without generating condensate.

C. The unit case shall be constructed of G90 galvanized, 20-gauge steel, with lapped corners and zinc plated screw fasteners.

D. Access doors shall provide easy access to blowers, ERV cores, and filters. Doors shall have an airtight compression seal using closed cell foam gaskets. Pressure taps, with captive plugs, shall be provided allowing cross-core pressure measurement allowing for accurate airflow measurement.

E. Case walls and doors shall be insulated with 1 inch, 4 pound density, foil/scrim faced, high-density fiberglass board insulation, providing a cleanable surface and eliminating the possibility of exposing the fresh air to glass fibers, and with minimum R-value of 4.3 (hr·ft2·°F/BTU).

F. The ERV cores shall be protected by a MERV-8 rated, 2" nominal, pleated, disposable filter in both airstreams.

G. Unit shall have single-point power connection and a single-point 24 VAC contactor control connection.

H. Blower motors shall be Premium Efficiency, EISA compliant for energy efficiency. The blower motors shall be totally enclosed (TEFC) and be shall be supplied with factory installed motor starters. Direct drive models shall be EISA-compliant for energy efficiency with open drip proof design and integral thermal protection.

I. Blowers shall be quiet running, forward curve type and be either direct drive or belt drive. Belt drive motors shall be provided with adjustable pulleys and motor mounts allowing for blower speed adjustment, proper motor shaft orientation and proper belt tensioning.

J. The unit electrical box shall include a factory installed, non-fused disconnect switch and a 24 VAC, Class II transformer/relay package.

K. The ERV shall be provided “inverter-ready” allowing for applications of inverters supplied and installed by others.

2.2 OPTIONS

A. Provide unit and duct connection orientation per project schedule.

B. Provide double wall construction with 24-gauge galvanized steel liner.

C. Units are available single or three phase at a full range of operating voltages. See project schedule.

D. Provide motor horsepower as specified in project schedule.

E. Provide factory installed disconnect fuses.

F. Provide factory installed filter monitors for each airstream.

G. Provide MERV-13 filters for final installation after construction phase.

H. Provide ECM controlled motors allowing for to preset speeds or variable speed operation with a 0-10 volt DC control signal.

I. Provide factory installed isolation dampers for either or 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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Unit Location

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. Provide a roof curb.

B. Vibration Isolation

1. Provide rubber or spring type isolators appropriately sized for corner weights of the specific unit.
2. Provide flexible duct connections at unit duct flanges.

C. Duct Design

1. All ductwork shall be designed, constructed, supported and sealed in accordance with SMACNA HVAC Duct Construction Standards and pressure classifications.
2. At a minimum all duct runs to the outdoors shall be thermally insulated at levels appropriate to the local climate. A continuous vapor barrier shall also be provided on warm surface of the insulation.

D. Test and Balancing

1. Test and Balancing may not begin until 100% of the installation is complete and fully functional.
2. 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.

END OF SECTION 23 72 19

SECTION 23 74 00 - PACKAGED ROOFTOP AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Packaged Rooftop Units

B. Unit Accessories

C. Unit Controls

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Common Motor Requirements for HVAC Equipment

D. Division 23 – Vibration Isolation and Seismic Restraints for HVAC

E. Division 23 – Sequence of Operation

1.3 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210

B. Sound Ratings: AMCA 301, Tested to AMCA 300

C. Fabrication: Conform to AMCA 99

1.4 REFERENCES

A. AMCA 99 – Standard Handbook

B. ARI670 – Fans and Blowers

C. International Energy Conservation Code 2015

D. ASHRAE 90.1-1999

1.5 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities of selected model clearly indicated; dimensions; required clearances; location and size of field connections; shipping, installed, and operating weights; electrical nameplate data; control and power wiring diagrams; furnished specialties; accessories; and installation and startup instructions.

B. Shop Drawing: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Commissioning Reports: Indicate results of startup and testing commissioning requirements. Submit copies of checklists.

D. For substitutions, submit layout and with factory service clearances indicated.

E. Noise Criteria: Submit certified noise criteria and distance measured at.

F. Warranties: Special warranties specified in this Section.

G. Submit manufacturer's installation instructions under provisions of Division 23.

H. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which condensing units will be attached.

I. Manufacturer Seismic Qualification Certification: Submit certification that units of this section, accessories, and components will withstand seismic forces defined in Division 23, Section "Vibration Isolation and Seismic Restraints for HVAC Components." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

J. Field quality-control test reports.

K. Structural steel fabrication and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings, roof hatches, duct through roof penetrations, expansion joints, etc.) Exact sizes and exact locations of openings are to be verified with the approved shop drawings issued for the installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. Sizes and locations indicated on Contract Drawings are diagrammatic and for information only. Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacturer and must be repaired, relocated, altered, replaced, re-installed or modified in any manner will be done to the satisfaction of the Owner with no additional cost to the Owner or design professional.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 23.

B. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

1.7 QUALITY ASSURANCE

A. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

B. Energy Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

C. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

1. The rooftop unit(s) shall be certified in accordance with UL Standard 1995 and ANSI Standard Z21.47
2. The rooftop unit(s) shall be safety certified by an accredited testing laboratory and the nameplate shall carry the label of the certification agency.

1.8 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver, store, protect and protect products under provisions of Division 23.

B. Protect units from physical damage by storing off site until roof mounting frames are in place, ready for immediate installation of units.

C. Deliver rooftop units as factory-assembled units with protective crating and covering as recommended by the manufacturer.

D. Coordinate delivery of units in sufficient time to allow movement into building.

E. Handle rooftop units to comply with manufacturer's written rigging and installation instructions for unloading and moving to final location.

1.9 WARRANTY

A. Provide one year warranty on parts and labor from Date of Final Acceptance.

B. Include 5 year compressor parts and labor warranty from Date of Final Acceptance.

C. Include 10 year parts and labor warranty on the gas fired heat exchanger from Date of Final Acceptance

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. AAON (Basis of Design)

B. Reviewed Equivalent by Trane, McQuay or Carrier

2.2 ROOFTOP UNITS

A. Manufacturers other than the Basis of Design, must submit a detailed 1/4" per foot scale layout including proposed unit locations with manufacturer’s recommended clearances around each unit for accessibility, maintenance requirements, ductwork layouts including interferences with structural members clearly identified and resolved, proposed ductwork fittings and elbows and including static pressure calculations and electrical service change requirements resulting from deviations from the original design, min 10'-0" distances between intake air locations and exhaust fan outlet locations clearly identified, performance data and deviations from design clearly identified, fan curves with the operating point clearly identified and performance criteria. Any work resulting in cost increases due to the proposed substitutions shall be borne by the manufacturer proposing the units. The layouts and information shall be reviewed by the Engineer for conformance to the present intended layout and the design concept which takes into consideration the above mentioned factors.

B. Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise, or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding**.

C. Description: Factory assembled and tested; designed for roof installation; and consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, gas heater, enthalpy wheels, filters, and dampers.

D. Construction:

1. Unit shall be completely factory assembled, piped and wired and shipped in one section.
2. Unit shall be specifically designed for outdoor roof top application with a fully weatherproof cabinet.
3. Cabinet shall be constructed entirely of G90 galvanized steel with the exterior constructed of 20 gauge or heavier material.
4. Paint finish shall be capable of withstanding at least 2000 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
5. The unit roof shall be sloped or cross-broken to assure drainage.
6. Unit specific color coded wiring diagrams shall match the unit color coded wiring and will be provided in both point-to-point and ladder form.
7. Diagrams shall also be laminated in plastic and permanently affixed inside the control compartment.
8. Access to filters, blower, heating section, and other items needing periodic checking or maintenance shall be through hinged access doors with quarter turn latches. Door fastening screws are not acceptable.
9. Access doors shall have stainless steel hinges and full perimeter gasketing.
10. All openings through the base pan of the unit shall have upturned flanges of at least 1/2" in height around the opening through the base pan.
11. Air side service access doors shall have rain break overhangs.
12. All access doors shall have an internal metal liner to protect the door ½ inch thick, 1½ lb. density fiberglass insulation.
13. The interior air side of the cabinet shall be entirely insulated on all exterior panels with 1 inch thick, 1 1/2 lb. density fiberglass insulation.
14. Unit shall have decals and tags to indicate unit lifting and rigging, service areas and caution areas. Installation and maintenance manuals shall be supplied with each unit.
15. Unit shall be furnished with 304 stainless steel drain pans.

E. Supply Fans:

1. Blower(s) shall be entirely self contained on a slide deck for service and removal from the cabinet. All belt drive blower(s) shall have backward inclined airfoil blades.
2. Adjustable V-belt drive shall be provided with a minimum rating of 140% of the motor nameplate brake horsepower when the adjustable pulley is at the minimum RPM.
3. Blowers, drives and motors shall be dynamically balanced.
4. All fan motors shall be non-overloading with motor horsepower selected at the discretion of the Engineer. Fan motors that are VFD driven shall be premium efficiency; or else they shall be high efficiency.
5. Supply and return photoelectric type smoke detectors. Furnish remote mounting (field) detector test indicating panels.

F. Outside Air Section:

1. Shall be a fully modulating economizer with a DDC signal. The outside air damper and return air damper assembly shall be constructed of extruded aluminum, hollow core, air foil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 25 CFM of leakage per sq. ft. of damper area

when subjected to 2 in. w.g. air pressure differential across the damper. Damper motor shall be spring return to ensure closing of outdoor air damper during periods of unit shut down or power failure.

2. Units shall be powered relief for units 3000 cfm and above. All relief fan motors shall be VFD driven and non-overloading with motor horsepower at the discretion of the Engineer. VFD's shall modulate based on actual OSA flow and the unit controller shall have an algorithm to accomplish this sequence. Balancing agency and manufacturer's startup technicians shall work together and be responsible for setting the fan speed based on actual air intake volume throughout the entire OSA airflow range (verified thru balancing equipment). The relief air volume shall track the OSA intake volume. Provide an Ebtron GTA-116P airflow station and differential pressure transmitter.

G. Energy Recovery Wheel (Where Scheduled):

1. The rooftop unit shall have a factory mounted and tested energy recovery wheel. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings.
2. The energy recovery cassette shall be rated in accordance with ARI Standard 1060 and shall bear the ARI certification symbol.
3. The energy recovery cassette shall contain a total energy recovery heat wheel constructed of a light weight polymer material with permanently bonded desiccant coating. The energy recovery wheel media shall be capable of removal from the cassette and replacement without the use of tools. Wheel media shall be cleanable using hot water or light detergent without degrading the efficiency.
4. A Mechanical Purge shall be provided with a field adjustable damper assembly across the return air opening. The damper adjustment should be at maximum outside air flow to achieve negative (.010 w.g.) pressure in the exhaust section of the heat wheel to limit cross contamination of exhaust and incoming air to no more than 1%.
5. The exhaust fan shall be backward inclined type. Fan(s) and motor(s) shall be dynamically balanced. A back draft damper shall be included with the exhaust fan. Outside air filters shall be 4 inch, pleated, disposable, with an ASHRAE dust-spot efficiency of 30%, MERV 8. Motors shall be high efficiency. Motors for use with VFD shall be premium efficiency inverter rated only. Motor bearings shall be ball bearing and shall have external lubrication connections.

H. Condenser Section:

1. Air Cooled Condenser Section:

    a. The condensing section shall be equipped with vertical discharge axial flow direct drive fans. Direct drive fans shall be directly connected to and supported by the motor shaft.
    b. The condenser coils shall be sloped at least 30 degrees to protect the coils from damage.
    c. Condenser coils shall be copper tubes with aluminum fins mechanically bonded to the tubes.
    d. Condenser coils to be sized for a minimum of 10°F of refrigerant sub-cooling.

I. Filters: 4-inch- thick, fiberglass, throwaway with an ASHRAE dust-spot efficiency of 30%, MERV 8.

J. Evaporator Coils:

1. Evaporator coils shall be copper tube with aluminum fins mechanically bonded to the tubes.
2. Evaporator coils shall have galvanized steel end casings.
3. Evaporator coils shall have equalizing type vertical tube headers.
4. Evaporator coils shall be furnished with a thermostatic expansion valve.
5. Evaporator coils shall be furnished with a double sloped drain pan for the positive drainage of condensate.
6. Evaporator coil drain pan(s) shall be fabricated of Type 304 stainless steel.

K. Refrigeration System:

1. Compressors shall be scroll type with internal thermal overload protection and mounted on the compressor manufacturer's recommended rubber vibration isolators. Each compressor shall have independent refrigerant circuits.
2. All units over 7 tons shall be multiple stage and shall have a minimum of 2 stages of capacity control.
3. Compressors shall be mounted in an isolated compartment to permit operation of the unit without affecting air flow when the door to the compartment is open.
4. Compressors shall be isolated from the base pan and supply air to avoid any transmission of noise from the compressor into the building area.
5. System shall be equipped with thermostatic expansion valve type refrigerant flow control.
6. System shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant controls.
7. Unit shall be equipped with Schrader type service fittings on both the high side and low pressure sides of the system.
8. Unit shall be equipped with refrigerant liquid line driers.
9. Unit shall be fully factory charged with refrigerant. R-454B.

   a. Hot gas bypass shall be provided on the first refrigerant circuit.
   b. Each compressor shall be individually staged for capacity control.
   c. Unit shall be provided with a hot gas reheat coil and modulating hot gas reheat control valve piped to the lead refrigerant system
   d. Unit shall be equipped with a 5 minute anti-short cycle delay timer for each stage.
   e. Unit shall be equipped with 20 second between stage delay timers for each stage.

L. Gas Heating Section: (Where Applicable)

1. Unit shall heat using natural gas and be equipped with a modulating gas valve, adjustable speed combustion blower and stainless steel tubular heat exchanger. The heat exchanger shall have a minimum 10 year non pro-rated warranty on parts and labor from Date of Final Acceptance. The completely factory mounted gas heating assembly shall be capable of operating at any firing rate between 100% and 30% of rated capacity. The combustion air and gas firing rate shall both be capable of modulation.

2. A discharge air sensor shall be provided for field installation in the supply air ductwork to sense the discharge air temperature. The discharge air setpoint shall be adjusted at the electronic controller within the rooftop unit control compartment.
3. Heating control shall be capable of operation initiated by the control system.
4. Firestat – in each unit sensing the supply air, to de-energize the unit.

M. Hot Water Heating Coil (Where Applicable)

1. Unit shall be provided with two row hot water heating coil with copper tubes and aluminum fins mechanically bonded to the tubes.

N. Accessories

1. Low Limit Controls – shall be factory a mounted temperature limit switch. Mounted in the unit, supply airstream to shut off unit when discharge temperature reaches setpoint. The switch is adjustable from -30ºF to 100ºF, and is manually reset by disconnecting power to the unit.
2. Phase & Brown Out Protection shall include a 3 phase power monitor that shuts down the unit if the supplied power phases are out of balance, or over/under voltage, or in case of a phase loss. It protects motors and compressors from electrical phase loss or low voltage brownout. Reset shall be automatic.
3. Gas vent extension kits with flanged outlet to connect to Contractor fabricated extension flue.
4. Smoke detector(s) shall be furnished under Division 26 and installed in the unit where indicated by the Mechanical Contractor. All wiring shall be provided under Division 26.
5. Unit shall be provided with HW Defrost adjustable temperature sensor and timer wired to periodically stop the heat wheel rotation and allow warm exhaust air to defrost the wheel.

O. Controls

1. Controls by FMCS contractor, refer to Division 23.
2. Unit shall be furnished with terminal strip for interface to BMS.

P. Electrical Power Panel:

1. Unit shall be provided with a factory installed and wired internal disconnect and single point power connection.
2. Unit shall be provided with phase and brown-out protection to shut down all motors in the unit if the phases are more than 10% out of balance on voltage, or the voltage is more than 10% under design voltage or on phase reversal. Provide main and coated power fusing.
3. Unit shall be provided with a factory installed and field wired 115 volt, 15 amp ground fault service receptacle.
4. Power factor correction capacitors shall be applied to the compressors only and shall achieve 95% power factor.

2.3 Adapter Curb

A. Provide all labor, materials and equipment in connection with the complete installation of the Adapter Curb. Curb shall be designed to transition seamlessly from your existing roof curb to new equipment without penetrating the roof membrane.

B. All adapters are fully insulated with customized internal dividers that allow for smooth airflow transition for supply and return airstreams.

C. Custom Prefabricated roof curb to be manufactured of prime galvanized steel construction, 14 gauge, meeting ASTM A653/653M, with welded corners and with seams joined by continuous water and air tight welds. Roof curb shall be internally reinforced with angles 48" on center and factory installed wood nailer. Top of all roof curbs shall be level, with pitch built into curb when deck slopes

D. Each curb is specifically engineered for proper load distribution of the unit to be installed. See Specification 23 05 46 for Vibration Isolation requirements.

E. Pre-fabricated isolation rail to be manufactured of prime galvanized steel, meeting ASTM A653/653M, with welded corners. Isolation rail shall be designed to connect unit openings to exisitng curb openings via the use of pre-installed duct transitions. Unit shall have adjustable spring isolators with non-conductive material minimizing sound transitions and designed to provide a minimum of 90% isolation efficiency with 2” deflection springs. A removable EPDM weathershield shall allow access to the isolators.

F. Adapter Curbs shall be constructed using minimum 14 gauge galvanized steel with fully welded corners, 2”, R-12 curb liner insulation on inside of curb. Provide 18 gauge internal curb liner.

G. Transition Ducts to contain 1” internal duct liner on air impacted surfaces, and 18 gauge galvanized steel turning vanes as per SMACNA requirements.

H. Minimum curb height: 14” above existing roof curb.

I. Curb shall be custom fabricated to transition from new unit supply and return air openings to existing curb openings while accommodating the site specific conditions. Manufacture’s representative to field verify site conditions.

J. Adapter Curbs shall be installed in strict accordance with manufacturers printed instructions and as detailed on drawings.

K. Size of Curbs and required options shall be coordinated by support manufacturer with general contractor and mechanical contractor prior to fabrication.

L. Adapter Curbs shall be guaranteed against defects in material and/or workmanship for a period of one(1) year.

M. Adaptor Curb shall be by Thy Curb, AES, SMS Specialists or Reviewed Equivalent.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation of rooftop units shall be the responsibility of the Mechanical Contractor. Follow the manufacturer's written installation instructions.

B. Any rigging devices (cranes, scaffolds) required shall be provided by the installing (Mechanical) Contractor.

3.2 EXAMINATION

A. Verify that roof is ready to receive work and opening dimensions are as illustrated by the manufacturer.

B. Verify that proper power supply is available.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide sheave and belt change-outs as required for final system balance requirements.

C. Extend combustion flue outlets to top of parapet height. Flue material shall be Type 304 stainless steel and be sized same as manufacturer's outlet. Construct vents with all welded joints and flanged inlet connection for ease of removal when unit doors are accessed for service.

D. Set two alternating layers of 5/8" thick fire rated drywall and two layers hushcore DS-52 acoustical treatment under entire unit. See Division 23 Ductwork Insulation for specification of acoustical insulation within roofcurb. Installation of cementious board/acoustical insulation shall be performed prior to setting of units on curbs and must be witnessed by the Architect/Engineer.

E. Ductwork penetrations through the roof shall be sealed with acoustical fill and acoustical grade caulk in order to eliminate gaps and resulting noise paths.

F. Provide flexible connections on ductwork systems connected to each rooftop unit.

G. Check belt alignment and adjust as required.

H. Check belt tension and adjust as required.

I. Set units on roofcurbs. Turn over roofcurbs to the General Contractor for installation and roofing/flashing.

J. Check unit safeties and interlocks with fire alarm system.

K. Check unit operation for compliance with the sequence of operation.

L. Install clean filters upon Final Acceptance of Project.

M. Install clean filters (minimum MERV 13) upon Final Acceptance of Project after all finishes have been installed, prior to occupancy, and prior to building flush-out.

3.4 MANUFACTURER'S FIELD SERVICES

A. Provide for initial start-up and shut-down during first year of operation, including routine servicing and check-out.

B. Provide programming of the unit for optimum start/stop, morning cool-down cycle, morning warm- up cycle, timed override, date (daily, weekly, monthly, holiday, etc) occupied and unoccupied periods as well as all programming required for the sequence of operation.

3.5 TESTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

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 unit operation. Remove malfunctioning units, replace with new units, and retest.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 TRAINING

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

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 01 and Division 23.

B. Schedule training with Owner, through Architect, with at least seven days advance notice.

END OF SECTION 23 74 00

SECTION 23 74 50 - WATER-SOURCE HEAT PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following types of water-source heat pumps:

1. Water-to-Water heat pump units.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each model.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

D. Product Certificates: For each type of water-source heat pump, signed by product manufacturer.

1. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For water-source heat pumps to include in emergency, operation, and maintenance manuals.

G. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of water-source heat pumps and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with ASHRAE 15.

D. Comply with minimum COP/efficiency levels according to ASHRAE/IESNA 90.1.

E. Comply with NFPA 70.

F. Comply with safety requirements in UL 484 for assembly of free-delivery water-source heat pumps.

G. Comply with safety requirements in UL 1995 for duct-system connections.

1.5 COORDINATION

A. Coordinate layout and installation of water-source heat pumps and associated piping.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.6 WARRANTY

A. Standard Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water-source heat pumps that fail in materials or workmanship within one year from date of final acceptance. Provide Parts & Labor Warranty.

B. Extended 4-year refrigeration circuit warranty covers heat exchangers, reversing valve, expansion valve and compressor for a total of 5 years from date of final acceptance.

C. Extended 4-year control board warranty covers the control board for a total of 5 years from date of final acceptance

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. ClimateMaster- (Basis of Design)

B. Carrier

C. Waterfurnace

2.2 WATER-SOURCE HEAT PUMPS

A. General:

1. Furnish and install Water-to-Water Heat Pumps as indicated on the plans. Equipment shall be completely assembled, piped, and internally wired. Capacities and characteristics as listed in the schedule and the specifications that follow.
2. Units shall be supplied completely factory built capable of operating over an entering water temperature range from 20° to 120°F (-6.7° to 48.9°C) as standard. Equivalent units from other manufacturers may be proposed provided approval to bid is given 10 days prior to bid closing. All equipment listed in this section must be rated and certified in accordance with Air-Conditioning, Heating and Refrigeration Institute/International Standards Organization (AHRI/ISO 13256-1). All equipment must be tested, investigated, and determined to comply with the requirements of the standards for Heating and Cooling Equipment UL-1995 for the United States and CAN/CSA-C22.2 NO.236 for Canada, by Intertek Testing Laboratories (ETL). The units shall have AHRI/ISO and ETL-US-C labels.
3. All units shall be fully quality tested by factory run testing under normal operating conditions as described herein. Quality control system shall automatically perform via computer: triple leak check, pressure tests, evacuation and accurately charge system, perform detailed heating and cooling mode tests, and quality cross check all operational and test conditions to pass/fail criteria. Detailed report card will ship with each unit displaying status for critical tests and components. Note: If unit fails on any cross check, it shall not be allowed to ship. Serial numbers will be recorded by factory and furnished to contractor on report card for ease of unit warranty status. Units tested without water flow are not acceptable.

B. Basic Construction:

1. All units must have multiple removable panels for serviceability of compressor compartment. Units having only one access panel shall not be acceptable. Service panels shall have Allen head three-quarter turn quick release latches, and hand hold pockets for easy removal.
2. The heat pumps shall be fabricated from heavy gauge galvanized steel with powder coat paint finish. Both sides of the steel shall be painted for added protection. All interior surfaces shall be lined with 1/2 inch (12.7mm) thick, 1-1/2 lb/ft3 (24 kg/m3) acoustic type glass fiber insulation.
3. Standard cabinet panel insulation must meet NFPA 90A requirements, air erosion and mold growth limits of UL-181, stringent fungal resistance test per ASTM-C1071 and ASTM G21, and shall meet zero level bacteria growth per ASTM G22. Unit insulation must meet these stringent requirements or unit(s) will not be acceptable.
4. The frame design shall consist of heavy gauge galvanized steel with powder coat finish. The module must have a low center of gravity base with cutouts for forklift or pallet jack and the frame must be designed to fit through a standard 36 inch doorway.
5. Cabinets shall have separate holes and knockouts for entrance of line voltage and low voltage control wiring. All factory-installed wiring passing through factory knockouts and openings shall be protected from sheet metal edges at openings by plastic ferrules.

Supply and return water connections shall be copper FPT fittings. Contractor shall be responsible for any extra costs involved in the installation of units that do not have this feature. Contractor must ensure that units can be easily removed for servicing and coordinate locations of electrical conduit and lights with the electrical contractor..

6. Unit(s) shall have exterior indicator lights showing, 1) power (on-Green), 2) unit “fault” status (fault - Red), 3) compressor 1 operation (on-Green), and 4) compressor 2 operation (on-Green). Contractor shall be responsible for providing control circuitry and indicator lights for units not providing this feature.

C. Refrigerant Circuit:

1. Units shall have sealed, isolated refrigerant circuits, each including a high efficiency scroll compressor designed for heat pump operation, a thermostatic expansion valve for refrigerant metering, a reversing valve, sight glass, filter dryer, load and source brazed plate refrigerant to water heat exchangers, and safety controls including a high pressure switch, low pressure switch (loss of charge), and low water temperature sensors. Access fittings shall be factory installed on high and low pressure refrigerant lines to facilitate field service. Activation of any safety device shall prevent compressor operation via a microprocessor lockout circuit.
2. Hermetic compressors shall be internally sprung. The compressors will be mounted on specially engineered sound-tested EPDM vibration isolation grommets to a large heavy gauge base plate. Compressors shall have thermal overload protection. Each compressor shall have isolation switch to aid start-up and service. Units without isolation switch are not acceptable.
3. Heat exchangers shall be highly efficient, refrigerant to water, dual circuited, brazed plate design, constructed of 316 stainless steel; designed, tested, and UL stamped in accordance with ASME Section VIII pressure vessel code for 650 PSIG (4482 kPa) working refrigerant pressure. The heat exchangers shall be mounted to eliminate the effect of migration of refrigerant to the cold evaporator with consequent liquid slugging on start-up. The heat exchangers shall be mounted on two layers of noise attenuating rubber isolation pads which also acts as a thermal barrier. The heat exchangers shall be wrapped with 3/4 inch closed cell insulated blanket and closed cell insulation shall be provided on suction side refrigerant tubing to prevent condensation.
4. Units shall be shipped with factory charged refrigerant (R410A) and refrigerant oil.
5. Unit shall have sound blanket on compressors.

D. Water Circuit:

1. Unit shall have all internal water tubing insulated with closed cell insulation. Field connections shall be on the top so multiple units can be installed side by side. PT ports and heat exchanger flushing connections shall be accessable from back service panel. Load and source water shall be tested and results approved by manufacturer to activate warranty.
2. Unit shall have Source Motorized Valve to prevent unit from locking out when water temperature is below 60ºF in cooling mode. Valve will automatically modulate to maintain compressor head pressure, for continuous unit operation.
3. External of unit, contractor must supply the following: minimum 60 mesh stainless steel screen strainers (for Load and Source), pressure taps. All components should be isolated for ease of service.

4. Unit requires field-installed pressure differential sensors ADPS for Load and Source due to low pressure delta. Sensors to be mounted external of unit.
5. Motorized valve for Load and/or Source. Used when variable speed pumps are incorporated on Load and or Source circuit.
6. Y Strainer for Load side and basket strainer for Source side. Available from factory.

E. Electrical:

1. The control box shall consist of a NEMA Type I enclosure with high and low voltage compartments, components include: low voltage connection block, power distribution block, compressor fusing, contactors, finger safe control fusing, transformer, isolation relays, status and alarm relay, 16-bit microprocessor DDC controller with built in native Building Automation System (BAS) communication protocols (BACnet and Modbus) two isolation switches to disable each individual compressor during start-up or troubleshooting, and external status indicating lights.

F. Controls

1. Controls by FMCS Contractor, refer to Division 23.
2. Unit shall be furnished with terminal strip for interface to BMS system to provide existing sequence of controls.

G. Field Installed Options

1. Valves: The following valves are available and will be shipped loose: for field installation.

    a. Ball valve; bronze material, standard port full flow design, FPT connections.
    b. Ball valve with memory stop and PT port.
    c. Motorized water valve; slow acting, 24v, FPT connections.

2. Strainers: The following strainers are available and will be shipped loose: for field installation.

    a. 3” FPT Y-strainer. 60 mesh screen.
    b. 3” FPT Basket strainer. 60 mesh screen.

3. Hose Kits:

    a. All units shall be connected with hoses. The hoses shall be 2 feet (61 cm) long, braided stainless steel; fire rated hoses complete with adapters. Only fire rated hoses will be accepted.

4. Water pressure differential sensors: ADPS – used for proof of water flow. Field installed required on both Source and Load side. 3 way switch: (not required if connected to BAS) field obtained and installed operation mode switch selects – off, cool, heat.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of water-source heat pumps.

B. Examine roughing-in for piping and electric installations for water-source heat pumps to verify actual locations of piping connections and electrical conduit before installation.

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

3.2 INSTALLATION

A. Install units on concrete bases. Refer to Division 23 requirments.

B. Install wall-mounting thermostats, and switch controls in electrical outlet boxes at heights to match lighting controls.

3.3 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Connect supply and return hydronic piping to heat pump with hard piping.

B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

C. Install piping adjacent to machine to allow service and maintenance.

D. Ground equipment according to Division 16 Section "Grounding and Bonding."

E. Connect wiring according to Division 16 Section "Conductors and Cables."

F. Refer to Equipment Electrical Matrix on drawings for direction on electrical disconnects and wiring to unit.

3.4 FIELD QUALITY CONTROL

A. Comply with Section 01 81 13.13, Sustainable Design Requirements for LEED. While complete compliance with Section 01 81 13.13 is mandatory, specific requirements related to LEED Energy and Atmosphere Credit 3 (Enhanced Commissioning) shall be referenced under 1.5.D.13 — provide all testing documentation to the commissioning authority (CxA) and address all requests or directives issued by the CxA.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

C. Perform the following field tests and inspections and prepare test reports:

1. After installing water-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
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.

D. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to compressor, coils, and components.
3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.
7. Adjust vibration isolators.
8. Start unit according to manufacturer's written instructions.
9. Complete startup sheets and attach copy with Contractor's startup report.
10. Inspect and record performance of interlocks and protective devices; verify sequences.
11. Operate unit for an initial period as recommended or required by manufacturer.
12. Verify thermostat calibration.
13. Inspect controls for correct sequencing of heating, cooling, refrigeration, and normal and emergency shutdown.
14. Start each unit and measure and record the following:

    a. Entering chilled water temperature.
    b. Leaving chilled water temperature.
    c. Chilled water flowrate.
    d. Chilled water pressure drop.
    e. Condenser entering water temperature during chilled water generation.
    f. Condenser leaving water temperature during chilled water generation.
    g. Condenser water flowrate during chilled water generation.
    h. Condenser water pressure drop during chilled water generation.
    i. Entering heating water temperature.
    j. Leaving heating water temperature.

k. Heating water flowrate.
l. Heating water pressure drop.
m. Condenser entering water temperature during heating water generation.
n. Condenser leaving water temperature during heating water generation.
o. Condenser water flowrate during heating water generation.
p. Condenser water pressure drop during heating water generation.

3.6 ADJUSTING

A. Adjust temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months of date of Final Acceptance, 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.

3.7 CLEANING

A. After completing installation of exposed, factory-finished water-source heat pumps, inspect exposed finishes and repair damaged finishes.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water-source heat pumps. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION 23 74 50

SECTION 26 05 00 - COMMON WORK RESULTS - ELECTRICAL

PART 1 - GENERAL

1.1 EXECUTION OF THE WORK

A. These specifications call out certain duties of the Electrical Contractor and his Subcontractors. They are not intended as a material list of items required by the Contract. Any reference in these specifications and on the accompanying drawings to the Contractor, Electrical Contractor, Electrical Subcontractor or abbreviation "E.C.", shall be construed to mean the Contractor responsible for all electrical construction (Division 26) work for this project.

B. This division of the specifications covers the electrical systems of the project. It includes work performed by the electrical trades as well as trades not normally considered as electrical trades.

C. Provide all items and work indicated on the Drawings and all items and work called for in this division of the specifications in accordance with the conditions of Contract (Division 01 General Requirements Documents). This includes all incidentals, equipment, appliances services, hoisting, scaffolding, supports, tools supervision, labor consumable items, fees licenses, etc., necessary to provide complete systems. Perform start-up and checkout on each item and system to provide fully operable systems.

D. Comply with all provisions of the Contract Documents including the General Conditions, and Division 01 General Requirements of the specifications.

E. Certain terms such as "shall, provide, install, complete, start-up" are not used in some parts of these specifications. This does not indicate that the items shall be less than completely installed or that systems shall be less than complete.

F. Examine and compare the Electrical Drawings with these specifications and report any discrepancies between them to the Architect/Engineer and obtain from him written instructions for changes necessary in the work. At time of bid the most stringent requirements must be included in said bid.

G. Examine and compare the Electrical Drawings and Specifications with the Drawings and Specifications of other trades and report any discrepancies between them to the Architect/Engineer and obtain from him written instructions for changes necessary in the work. At time of bid, the most stringent requirements must be included in said bid.

H. Install and coordinate the electrical work in cooperation with other trades installing interrelated work. Before installation, make proper provisions to avoid interferences in a manner approved by the Architect/Engineer. All changes required in the work of the Contractor, caused by his neglect to do so, shall be made by him at his own expense.

I. It is the intent of the Drawings and Specifications to provide a complete workable system ready for the Owner’s operation. Any item not specifically shown on the Drawings or called for in the

Specifications, but normally required to conform to the intent, are to be considered a part of the Contract.

J. These specifications are basically equipment, installation, and performance Specifications. Some installation details are indicated on the Drawings. Where these differ from the Specifications, apply the more stringent at time of bid. Upon award of bid, contact Architect/Engineer for definite instructions.

K. All materials furnished by the Contractor shall be new and unused (temporary lighting and power products are excluded) and free from defects. All materials used shall bear the Underwriter's Laboratory, Inc. label provided a standard has been established for the material in question.

L. All products and materials shall be new, clean, free of defects and free of damage and corrosion.

M. The exclusion from, or limitation in, the symbolism used on the Drawings or the language used in the Specifications for electrical work shall not be interpreted as a reason for omitting the accessories necessary to complete any required system or item of equipment.

N. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.

O. Except for conduit, conduit fittings, outlet boxes, wire and cable, all items of equipment or material shall be the product of one manufacturer throughout. Multiple manufacturers will not be permitted.

P. Receive, inspect, store, install and wire Owner-furnished equipment where Owner furnished equipment is supplied.

Q. Painting

1. All manufactured electrical equipment such as panelboards, control equipment, lighting fixtures, etc., shall have factory-applied finish as specified in the appropriate article in the Electrical Parts of the Specification.
2. All other uncoated steel items such as boxes supports, hanger, rods, etc., shall be galvanized or have a shop coat of paint applied under this Part of the Specification. Normally shop coats shall be an approved primer containing at least 50 percent rust inhibitive pigment, applied before assembling the different parts.
3. Including painting and retouching of:

    a. Pre-finished enclosures of switchboards, panelboards, switches, wireways, etc., where the finish has been slightly damaged in transit before assembling the different parts.
    b. Any woodwork furnished in the electrical work.
    c. Fixture hangers, except those received from manufacturers that are prefinished.
    d. Miscellaneous iron brackets and supports.
    e. Steel conduits buried in earth (asphaltum).

4. Woodwork installed under this part of the specification shall be finished with filler sealer plus two (2) coats of PPG "Water Spar" gloss varnish.

1.2 COORDINATION OF THE WORK

A. Certain materials will be provided by other trades. Examine the Contract Documents to ascertain these requirements.

B. Carefully check space requirements with other trades and the physical confines of the area to ensure that all material can be installed in the spaces allotted thereto including finished suspended ceilings and the spaces within the existing building. Make modifications thereto as required and approved.

C. No items foreign to the electrical system shall be run in the dedicated space of the electrical equipment. Dedicated space shall be defined as the width and depth of the equipment from the floor to the bottom of the structural ceiling. Foreign systems include but are not limited to ductwork, piping, sprinklers, drip trays, etc. Contractor shall be responsible to coordinate the locations of the dedicated spaces with all trades as required.

D. Transmit to other trades all information required for work to be provided under their respective Sections in ample time for installation.

E. Wherever work interconnects with work of other trades, coordinate with other trades to ensure that all trades have the information necessary so that they may properly install all the necessary connections and equipment. Identify all items of work that require access so that the ceiling trade will know where to install access doors and panels.

F. Due to the type of installation, a fixed sequence of operation is required to properly install the complete systems. Coordinate, project and schedule work with other trades in accordance with the construction sequence.

G. The locations of lighting fixtures, outlets, panels and other equipment indicated on the Drawings are approximately correct, but they are understood to be subject to such revision as may be found necessary or desirable at the time the work is installed in consequence of increase or reduction of the number of outlets, or in order to meet field conditions or to coordinate with modular requirements of ceilings, or to simplify the work, or for other legitimate causes.

H. Exercise particular caution with reference to the location of panels, outlets, switches, etc., and have precise and definite locations approved by the Architect/Engineer before proceeding with the installation.

I. The Drawings show only the general run of raceways and approximate location of outlets. Any significant changes in location of outlets, cabinets, etc., necessary in order to meet field conditions shall be brought to the immediate attention of the Architect/Engineer and receive his approval before such alterations are made. All such modifications shall be made without additional cost to the Owner.

J. Obtain from the Architect/Engineer in the field, the location of such outlets or equipment not definitively located on the Drawings.

K. Circuit "tags" in the form of arrows are used where shown to indicate the home runs of raceways to electrical distribution points. These tags show the circuits in each home run and the panel designation. Show the actual circuits numbers on the finished record tracing and on panel directory card. Where circuiting is not indicated, Electrical Contractor must provide required circuiting in accordance with the loading indicated on the drawings and/or as directed.

L. The Drawings generally do not indicate the exact number wires in each conduit for the branch circuit wiring of fixtures, and outlets, or the actual circuiting. Provide the correct wire size and quantity as required by the indicated circuiting and/or circuit numbers indicated and control, wiring diagrams, if any, specified voltage drop or maximum distance limitations, and the applicable requirements of the NEC.

M. Adjust location of conduits, panels, equipment, pull boxes, fixtures, etc. to accommodate the work to prevent interferences, both anticipated and encountered. Determine the exact route and location of each raceway (and bus duct) prior to fabrication.

1. Right-of-Way:

a. Lines which pitch have the right-of-way over those which do not pitch. For example: condensate and plumbing drains normally have right-of way. Lines whose elevations cannot be changed to have right-of-way over lines whose elevations can be changed.
b. Make offsets, transitions and changes in direction in raceways as required to maintain proper headroom in pitch of sloping lines whether or not indicated on the Drawings.

N. Wherever the work is of sufficient complexity, prepare additional Detail Drawings to scale similar to that of the bidding Drawings, prepared on tracing medium of the same size as Contract Drawings. With these layouts, coordinate the work with the work of other trades. Such detailed work shall be clearly identified on the Drawings as to the area to which it applies. Submit for review Drawings clearly showing the work and its relation to the work of other trades before commencing shop fabrication or erection in the field.

O. Contractor shall furnish services of an experienced Superintendent, who shall be in constant charge of all work, and who shall coordinate his work with the work of other trades. No work shall be installed before coordinating with other trades.

P. Coordinate with contractors for work under other Divisions of this specification for all work necessary to accomplish this contractor's work.

Q. Where electrical connections are required, to equipment provided by the Owner or by other trades, this Contractor shall verify the exact requirements for these connections prior to ordering any materials or laying out any work. Where there is a discrepancy between the equipment being furnished and that shown on the Contract Drawings, the Contractor shall notify the Architect/Engineer for direction. Failure to comply with this coordination shall not constitute a reason for extra monies for equipment ordered or installed. Restocking charges will not be paid.

1.3 EXAMINATION OF SITE

A. Prior to the submitting of bids, the Contractor shall visit the site of the job and shall familiarize himself with all conditions affecting the proposed installation and shall make provisions as to the cost thereof. Failure to comply with the intent of this paragraph will in no way relieve the contractor of performing all necessary work shown on the Drawings.

1.4 PROGRESS OF WORK

A. The Contractor shall order the progress of his work so as to conform to the progress of the work of other trades and shall complete the entire installation as soon as the conditions of the building will permit. Any cost resulting from the defective or ill-timed work performed under this section shall be borne by the Contractor.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Ship and store all products and materials in a manner which will protect them from damage, weather and entry of debris. If items are damaged, do not install, but take immediate steps to obtain replacement or repair. Any such repairs shall be subject to review and acceptance of the Architect/Engineer.

B. Delivery of Materials: Deliver materials in manufacturer's unopened container fully identified with manufacturer’s name, trade name, type, class, grade, size and color.

C. Storage of Materials, Equipment and Fixtures: Store materials suitably sheltered from the elements, but readily accessibly for inspection by the Architect/Engineer until installed. Store all items, susceptible to moisture damage, in dry, heated spaces.

1.6 EQUIPMENT ACCESSORIES

A. Provide supports, hangers and auxiliary structural members required for support of the work according to Section 26 05 29 "Hangers and Supports for Electrical Systems" and Section 26 05 48 "Vibration and Seismic Control for Electrical Components."

B. Furnish and set all sleeves for passage of raceways through structural, masonry and concrete walls or floors and elsewhere as will be required for the proper protection of each raceway passing through building surfaces.

C. Wall mounted equipment may be directly secured to wall by means of steel bolts. Maintain at least 1" air space between equipment and supporting wall. Groups or arrays of equipment may be mounted on adequately sized steel angles, channels, or bars. Prefabricated steel channels providing a high degree of mounting flexibility, such as those manufactured by Kindorf, Glob-Strutt and Unistrut, may be used for mounting arrays of equipment.

1.7 CUTTING, PATCHING

A. The work shall be carefully laid out in advance. Where cutting, channeling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support or anchorage of raceway, outlets or other equipment, the work shall be carefully done. Any damage to the building, piping, equipment or defaced finish plaster, woodwork, metalwork, etc. shall be repaired by skilled mechanics or the trades involved at no additional cost to the Owner.

B. The Contractor shall do no cutting, channeling, chasing or drilling of unfinished masonry, tile, etc., unless he first obtains permission from the Architect/Engineer. If permission is granted, the Contractor shall perform this work in a manner approved by the Architect/Engineer

C. Where conduits, mounting channels, outlet, junction, or pull boxes are mounted on a painted surface, or a surface to be painted, they shall be painted to match the surface. Whenever support channels are cut, the bare metal shall be cold galvanized.

D. Slots, chases, openings and recesses through floors, walls, ceilings, and roofs will be provided by the various trades in their respective materials. The trade requiring them to properly locate such openings and be responsible for any cutting and patching caused by the neglect to do so.

E. Structural steel fabricator and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings, roof hatches, smoke hatches, duct thru roof penetrations, expansion joints, etc.)

Exact sizes and exact locations of all openings are to be verified with the approved shop drawings issued for the installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. (Sizes and locations indicated on contract drawings are diagrammatic and for information only.)

Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacturer and must be repaired, relocated, altered, replaced, re-installed or modified in any manner will be done to the satisfaction of the Owner with no additional cost to the Owner or design professional.

1.8 FIRESTOPPING

A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire resistance of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping".

1.9 NORMAL VOLTAGES (Unless Otherwise Noted)

A. Primary Distribution – 4800 volts.

B. Secondary Distribution – 480/277 Volt, three phase, 4 wire and/or 208/120 Volt, three phase, 4 wire.

1.10 MOUNTING HEIGHTS

A. Unless otherwise noted or required because of special conditions, locate outlets as indicated on the drawings:

1. Heights listed are from finished floor to center of device. Verify exact locations with the Architect/Engineer before installation.

1.11 CLEANING UP

A. Contractor shall take care to avoid accumulation of debris, boxes, crates, etc., resulting from the installation of his work. Contractor shall remove from the premises each day all debris, boxes, etc., and keep the premises clean, subject to the Architect/Engineer's instructions, which shall be promptly carried out.

B. Contractor shall clean all fixtures and equipment at the completion of the project.

C. All switchboards, panelboards, wireways, cabinets, enclosures, etc. shall be thoroughly vacuumed clean prior to energizing equipment and at the completion of the project. Equipment shall be opened for observation by the Architect/Engineer as required.

1.12 WATERPROOFING

A. Avoid, if possible, the penetration of any waterproof membranes such as roofs, machine room floors, basement walls, and the like. If such penetration is necessary, perform it prior to the waterproofing and furnish all sleeves or pitch-pockets required. Advise the Architect/Engineer and obtain written permission before penetrating any waterproof membrane, even where such penetration is shown on the Drawings.

B. If Contractor penetrates any walls or surfaces after they have been waterproofed, he shall restore the waterproof integrity of that surface as directed by the Architect/Engineer at his own expense, using workmen skilled in that trade.

1.13 SUPPORTS AND FASTENERS

A. Provide supports, hangers and auxiliary structural members required for support of the work according to Section 26 05 29 "Hangers and Supports for Electrical Systems" and Section 26 05 48 "Vibration and Seismic Control for Electrical Components."

B. Furnish and set all sleeves for passage of raceways through structural, masonry and concrete walls or floors and elsewhere as will be required for the proper protection of each raceway passing through building surfaces.

C. Wall mounted equipment may be directly secured to wall by means of steel bolts. Maintain at least 1" air space between equipment and supporting wall. Groups or arrays of equipment may be mounted on adequately sized steel angles, channels, or bars. Prefabricated steel channels providing a high degree of mounting flexibility, such as those manufactured by Kindorf, Glob-Strutt and Unistrut, may be used for mounting arrays of equipment.

1.14 PROHIBITED LABELS AND IDENTIFICATIONS

A. Prohibited Markings: In all public areas, tenant areas and similar locations within the project, the inclusion or installation of any item, element or assembly which bears on any exposed surface any name, trademark, or other insignia which is intended to identify the manufacturer, the vendor, or other source(s) from which such object has been obtained, is prohibited. Also prohibited is the inclusion or installation of any article which bears visible evidence that an insignia, name, label, or other device had been removed.

B. Exception: Required Underwriter's Laboratory labels shall not be removed nor shall identification specifically required under the various technical sections of the specifications be removed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. If products and materials are specified or indicated on the Drawings for a specific item or system, use those products or materials. If products and materials are not listed in either of the above, use first class products and materials, subject to approval of Shop Drawings where Shop Drawings are required or as approved in writing where Shop Drawings are not required.

B. All equipment capacities, etc. are listed for job site operating conditions. All equipment sensitive to altitudes or ambient temperatures shall be derated and method of derating shown on Shop Drawings. Where operating conditions shown differ from the laboratory test conditions, the equipment shall be derated and the method of derating shown on Shop Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow manufacturer's instructions for installing, connecting, and adjusting all equipment. Provide one copy of such instructions to the Architect/Engineer before installing any equipment. Provide a copy of such instructions at the equipment during any work on the equipment. Provide all special supports, connections, wiring, accessories, etc.

B. Use mechanics skilled in their trade for all work.

C. Keep all items protected before and after installation. Clean up all debris.

D. Perform all tests required by local authorities in addition to tests specified herein, such as life safety systems.

E. Applicable equipment and materials to be listed by Underwriters' Laboratories and Manufactured in accordance with ASME, NEMA, ANSI or IEEE standards, and as approved by local authorities having jurisdiction as mentioned in Division 1.

F. Before commencing Work, examine all adjoining, underlying. Work on which this Work is in any way dependent for perfect workmanship and report any condition which prevents performance of first class work. Become thoroughly familiar with actual existing conditions to which connections must be made or which must be changed or altered.

3.2 PROJECT MANAGEMENT AND COORDINATION

A. Coordination: Coordinate construction operations included in different Sections of the Specification to ensure efficient and orderly installation of each part of the work. Coordinate construction operations, included in different Sections that depend on each other for proper installation, connection, and operation.

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components with other contractors to ensure maximum accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.
4. Where availability of space is limited, coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair of all components, including mechanical and electrical.

B. Prepare memoranda for distribution to each party involved, outlining special procedures required for coordination. Include such items as required notices, reports, and list of attendees at meetings.

1. Prepare similar memoranda for Owner and separate contractors if coordination of their work is required.

C. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities and activities of other contractors to avoid conflicts and to ensure orderly progress of the work. Such administrative activities include, but are not limited to, the following:

1. Preparation of Contractor's Construction Schedule
2. Preparation of the Schedule of Values
3. Installation and removal of temporary facilities and controls
4. Delivery and processing of submittals
5. Progress meetings
6. Pre-installation conferences
7. Project closeout activities
8. Startup and adjustment of systems
9. Project closeout activities

D. Conservation: Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials.

1. Salvage materials and equipment involved in performance of, but not actually incorporated into the work. Refer to other Sections for disposition of salvaged materials that are designated as Owner's property.

3.3 SUBMITTALS

A. Coordination Drawings: Prepare Coordination Drawings if limited space availability necessitates maximum utilization of space for efficient installation of different components or if coordination is required for installation of products and materials fabricated by separate entities.

1. Content: Project-specific information, drawn accurately to scale. Do not base Coordination Drawings on reproductions of the Contract Documents or standard printed data. Include the following information, as applicable:

    a. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems.
    b. Indicate required installation sequence.
    c. Indicate dimensions shown on the Contract Drawings and make specific note of dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Architect/Engineer for resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.

2. All submittals shall be provided electronically.
3. Refer to individual Sections for Coordination Drawing requirements for work in those Sections.

B. Key Personnel Names: Within 15 days of starting construction operations, submit a list of key personnel assignments, including superintendent and other personnel in attendance at Project Site. Identify individuals and their duties and responsibilities; list addresses and telephone numbers, including home and office telephone numbers. Provide names, addresses, and telephone numbers of individuals assigned as standbys in the absence of individuals assigned to Project.

1. Post copies of list in Project meeting room, in temporary field office, and by each temporary telephone. Keep list current at all times.

3.4 ADMINISTRATIVE AND SUPERVISORY PERSONNEL

A. General: In addition to Project Superintendent, provide other administrative and supervisory personnel as required for proper performance of the work.

END OF SECTION 26 05 00

SECTION 26 05 01 - SUMMARY OF WORK

PART 1 - GENERAL

1.1 SUMMARY

A. Provide the Work included in accordance with the Contract Documents.

B. Provide all labor, materials, equipment, tools, appliances, auxiliaries, services, hoisting, scaffolding, support, supervision, and Project Record Documents, and perform all operations for the furnishing and installing of the complete electrical system, including but not limited to the work described hereinafter. The work shall meet or exceed the latest codes, regulations and requirements required by the local Building Department (as mentioned in Division 01).

C. The electrical work is shown schematically on the Drawings to indicate the general system arrangement and configuration. The work of this Division shall include coordination with the work of other Divisions of the Specifications and the Contract Documents so as to provide a complete and operational system capable of being readily operated and maintained, including approved re-arrangement of the systems and equipment and re-routing of distribution services to enable the complete system to fit within the confines of the allotted electrical spaces, all to the satisfaction of the Architect/Engineer or as directed by the Architect/Engineer.

D. This specification encompasses work on two buildings within the School District. A separate summary of work for each follows. The work shall include but not limited to the following:

1. OFA High School / Middle School

    a. Panelboards (includes New or existing modifications).
    b. Electrical connections to new and replaced HVAC Equipment
    c. Feeder and branch circuits
    d. Wiring devices
    e. Fire alarm system modifications
    f. Grounding
    g. Identification
    h. Testing

1.2 SETTING OUT OF WORK

A. Layouts shown for mechanical equipment and elevator machine rooms are for estimating purposes only. Coordinate installation of conduit, outlets, luminaries, and equipment with final room equipment layout as supplied by equipment supplier.

B. Where switches, receptacles, fire alarm pull stations, are in the same general location, outlets shall be aligned vertically unless otherwise called for by the Architect. Comply with ADA mounting heights.

C. All equipment capacities, etc. are listed for job site operating conditions. All equipment sensitive to altitudes or ambient temperatures shall be derated and method of derating shown on the Shop Drawings.

D. Use mechanics skilled in their trade for all work.

E. Keep all items protected before and after installation. Clean up all debris.

F. Perform all tests required by local authorities in addition to tests specified herein, such as life safety systems.

G. Applicable equipment and materials shall be listed by Underwriters' Laboratories and manufactured in accordance with ASME, NEMA, ANSI or IEEE standards and as approved by local authorities having jurisdiction.

H. Before commencing work, examine all adjoining, underlying, etc., work on which this work is in any way dependent for perfect workmanship and report any condition which prevents performance of first class work. Become thoroughly familiar with actual existing conditions to which connections must be made or which must be changed or altered.

1.3 MECHANICAL EQUIPMENT WIRING

A. Division 23 Contractor/s shall furnish all motor starters/variable frequency drives and disconnect switches for their equipment. Division 26 Contractor shall install these devices, including wiring between motors and starters and between starters and disconnects including terminations.

B. Starters and disconnects for equipment such as overhead doors or non-Division 23 equipment shall be furnished, installed, wired and terminated by Division 26 Contractor.

END OF SECTION 26 05 01

SECTION 26 05 03 - CODES, FEES

PART 1 - GENERAL

1.1 DESCRIPTION

A. General: Comply with Codes in accordance with the Contract Documents.

1.2 CODES

A. The electrical installation shall comply with the 2015 Edition of National Electrical Code (NFPA 70 2017), 2015 Edition of the International Building Code, IBC 2018, 2020 New York State Energy Code and any other agency or authority having jurisdiction in this area.

B. All equipment shall be equal to or exceed the minimum requirements of N.E.M.A., I.E.E.E., and UL.

C. Should any change in Drawings or Specifications be required to comply with governmental regulations, the Contractor shall notify Architect/Engineer prior to execution of the Work. The work shall be carried out according to the requirements of such code in accordance with the instruction of the Architect/Engineer and at no additional cost to the Owner.

D. The provisions of Standards, Codes, Laws, Ordinances, etc., shall be considered minimum requirements. In case of conflict between their published requirements, the Owner's Representative shall determine which is to be followed and his decision shall be binding. Specific requirements of this specification and/or the drawings which exceed the published requirements shall take precedence over them.

1.3 FEES

A. All local fees and permits and services of inspection authorities shall be obtained and paid for by the Contractor. The Contractor shall cooperate fully with local companies with respect to their services. Contractor shall include in his bid; any costs to be incurred relative to power service (primary and/or secondary) and telephone service.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 NOT USED

END OF SECTION 26 05 03

SECTION 26 05 10 - TESTING, INSPECTION AND CERTIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. General – The Contractor shall completely test and inspect all systems in accordance with the specifications and drawings. The Contractor shall certify that all systems are in complete working order prior to turning over to the owner.

1.2 STANDARDS

A. Except as modified by governing codes and by the contract documents, comply with the latest applicable provisions and latest recommendations of the following:

1. NFPA
2. NEMA
3. NEC
4. IEEE
5. IPCEA
6. ANSI
7. UL
8. Local Fire Department

1.3 GENERAL TESTING

A. It shall be the responsibility of this Contractor to furnish all testing equipment and labor necessary to perform the following tests:

1. After wires or cables are in place, but before being connected to devices and equipment, the system shall be tested for shorts, opens, intentional and unintentional grounds. Wires or cables that are shorted or unintentionally grounded shall be replaced.
2. A voltage test shall be made on the last outlet of each branch circuit and the potential drop shall not exceed 2%. Voltage drops for panel and large feeders shall not exceed 3% hence the total voltage drop for a feeder and any branch circuit shall not exceed 5% of the service voltage. The test shall be made under design load or its equal.
3. Any wiring device or electrical apparatus in this contract, if grounded or shorted on an integral "line" part, shall be removed and the trouble corrected.
4. Complete test and inspection records shall be made and incorporated into a report for each piece of equipment tested. All readings taken shall be recorded. Four (4) copies shall be submitted to the Engineer for approval.
5. All tests must be conducted in the presence of Project Coordinator.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT AND MATERIALS

A. The Contractor shall provide all testing instruments, equipment and all materials, connections, etc., required to perform tests in accordance with these specifications.

PART 3 - EXECUTION

3.1 WIRING TEST

A. All wiring and cable tests shall be made before any circuits, main switch, motor, transformer or line is energized.

B. Tests shall be made for continuity, identification and absence of shorts and grounds for each conductor. Both ends of a given conductor shall be identified alike. Before circuit terminal connections are made, continuity and identification of wiring shall be checked by means of a DC test device using a bell, light, meter, or buzzer.

C. Insulation test shall be made at the following values:

480Y/277 Volt wiring at 1000 Volts DC
208Y/120 Volt wiring at 500 Volts DC

D. Insulation resistance between phase conductors and ground shall not be less than the minimum requirements of 2000 meg-ohms.

1. Wire terminations are not to be made to equipment (motors, VFD’s, etc.), until that piece of equipment has been tested and verified as specified in this section.
2. Test motor feeders with motors disconnected, but with circuit breakers, switches or starters in the circuit opened so as to include only that portion of the feeder it is desired to test.
3. Test lighting feeders with the circuit breakers and panelboards connected but with lighting branch circuit breakers or switches open so as to include only the feeder circuit desired to test.

E. Contractor shall correct or replace any circuit which is defective or grounded and he shall also correct all other troubles encountered by these tests. All defects whether due to faulty workmanship or material furnished by the Contractor shall be corrected under this section at the Contractor's expense in a manner acceptable to the Engineer.

3.2 LIGHTING TEST

A. Check all lighting fixtures for proper operation. All Contractor supplied fixtures shall be 100% operable at no additional cost to the Owner. Repair cost to the Owner supplied fixtures shall not be the responsibility of the Contractor unless otherwise stated.

3.3 MOTOR TEST

A. All 460 volt motors shall be individually "spot tested" for insulation resistance using 1000V DC. All 208/120V motors shall be "spot tested" with 500V DC in a similar manner. The minimum resistance to ground shall be 2000 meg-ohm (corrected to 20 degrees C). The Contractor shall record the ambient temperature of the motor and submit this value along with insulation resistance value.

B. Make the following checks on all motors prior to start-up:

1. Check motor name plates for H.P., speed, phase and voltage. Verify proper wiring.
2. Check shaft for freedom of rotation.
3. Verify that the motor is properly lubricated prior to energizing.

C. Contractor shall furnish a proper sized heater for each overload relay, where applicable. Notify the Engineer prior to installation of the motor full-load current rating, the number of overload relays, the starter catalog number, and the heater catalog number.

D. Make the following tests on all motors during or immediately after start-up:

1. Check for proper shaft rotation.
2. Check motor for smooth operation (vibration).
3. Take a current reading using a clamp-on ammeter. (No-load readings and loaded readings).

E. Equipment shall be put into operation after certification by the Contractor that the installation is satisfactory.

3.4 PANELBOARD

A. "Spot Test" all equipment to be operated on the 208/120V system at 500V DC prior to connecting feeders. A minimum insulation resistance of 2000 meg-ohms shall be obtained between all phases and between phase and ground.

3.5 TRANSFORMER (POWER 600V OR LESS) TEST

A. Insulation tests on transformers shall be as follows:

1. 480 Volts High Sides:

   "Spot Test" with 1000V DC, high side winding to low side winding and high side winding to ground. 2000 meg-ohm shall be the minimum acceptable insulation resistance.
2. 208/120 Volts Low Side:

   "Spot Test" with 500V DC, low side to ground. 2000 meg-ohm shall be the minimum acceptable insulation resistance.

3.6 SPOT TEST

A. "Spot Test" mentioned in this section shall be interpreted as the specific test method of obtaining insulation resistance by applying indicated test voltage for 60 seconds to the equipment or wiring being tested.

3.7 CONTROL WIRING/OUTLET TEST

A. Control wiring shall perform the function as noted in operation methods and/or included schematics and single line diagrams.

B. All 120 volt outlets shall be tested with a Daniel Woodhead Cat. No. 1750 and 1760 tester under the supervision of the Coordinator. Minimum acceptable tension is 4 oz. for NEMA 1-15R, and 5-20R, 6-15R, 6-20R, 7-15R, 7-20R, 14-15R, 14-20R, 15-15R and 15-20R.

END OF SECTION 26 05 10

SECTION 26 05 15 - CEILING, FLOOR AND WALL ELECTRICAL PENETRATION FIRE SEALS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General: Provide premixed putty sealant at ceiling and/or floor electrical penetration fire seals in accordance with the Contract Documents.

B. Related Work Specified in Division 26:

1.	Raceways and Boxes	Section 26 05 33
2.	Wires and Cable (0-1000V)	Section 26 05 21
3.	Penetration Firestopping	Section 07 84 13

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. ASTM E119-73
2. UL 1479

1.3 SUBMITTALS

A. Submit manufacturer's data for fire seal compound

B. Submit proof of approval by local authorities.

PART 2 – PRODUCTS

2.1 APPROVED MANUFACTURERS

A. Hilti Inc.

B. Nelson Firestop Products

C. Grace Construction Products

2.2 The system shall provide an immediate fire seal, require no curing time, emit no hazardous or toxic fumes and be asbestos free.

2.3 The system shall be easy to use, require no special tools and shall be capable of being installed from one side.

2.4 The system shall not require derating whatsoever of the wiring systems passing through the seal.

2.5 The system shall be field-modified for additions or deletions of raceways or cables.

2.6 Existing materials must be reusable to accommodate penetration changes.

2.7 The system shall maintain the fire rating of the structure it is protecting.

PART 3 – EXECUTION

3.1 GENERAL

A. Putty shall be installed no thinner than 0.75 inches.

D. A minimum of 0.5 inches of putty shall be placed around each penetrating item. When this is not possible, a cone shall be built up around the penetrating items, using a second layer of putty. Slope the cone at 30 degrees from wall or floor.

E. Wall openings must not have an unsupported space of putty greater than 4 inches and floor openings an unsupported opening of 1.5 inches.

F. Provide ceramic wool temperature rated 2300 degrees F. in conjunction with putty in accordance with the manufacturer's instructions

G. Provide ceramic fiberboard temperature rated 2000 degrees F. in conjunction with the putty in accordance with the manufacturer's recommendation

H. Penetrating items must be firmly anchored prior to the putty installation. Provide all necessary anchor bolts, fittings, etc., as necessary

3.2 INSTALLATION

A. Provide fire seals at all cable, conduit and bus duct penetrations through fire rated walls, floors and ceilings, and where noted on Drawings. Coordinate with architectural and structural drawings for location of fire rated walls.

B. Fire seal shall be installed in accordance with manufacturer's direction to provide a barrier rating equal to or greater than the barrier rating of the wall, floor or ceiling.

END OF SECTION 26 05 15

SECTION 26 05 21 - WIRES AND CABLES (0-1000V)

PART 1 - GENERAL

1.1 DESCRIPTION

A. General

1. Provide 600-volt wire and cable in accordance with the Contract Documents.

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. General: Underwriters' Laboratories labeling of all insulations and jackets.
2. Rubber Insulated Wire and Cables

    a. ICEA pub. No. S-19-81 (NEMA Pub. No. WC 3): Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
    b. UL 44: Rubber-Insulated Wires and Cables

3. Thermoplastic Insulated Wire and Cables

    a. ICEA pub. No. 1 S-614-02 (NEMA Pub. No. WC3): Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
    b. UL 83: Wires, Thermoplastic-Insulated

4. Cross Linked Thermosetting Polyethylene Insulated Wire and Cables

    a. ICEA pub. No. S-66-524: (NEMA Pub. No. WC7): Cross Linked Thermosetting Polyethylene Insulated Wire and Cable for Transmission and Distribution of Electrical Energy.
    b. UL 44: Rubber Insulated Wires and Cables
    c. UL 854: Service-Entrance Cables.

5. Annealed Copper Wire for Conductors

    a. ASTM B-3: Soft or Annealed Copper Wire

6. Terminal Blocks

    a. UL 1059

7. Insulation Thicknesses for Individual conductors

   a. N.E.C. Table 310-13: Conductor Application and Insulations.

1.3 SUBMITTALS

A. Provide listing of manufacturers proposed for this project.

1.4 RELATED WORK SPECIFIED IN DIVISION 26

A. Section 26 05 10 – Testing, Inspection and Certification.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver wire and cable to job site on reels or coils marked in accordance with N.E.C. Section 310-11.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Wire and Cable:

   1. Anaconda
   2. The Okonite Company
   3. Phelps Dodge Copper Products Corporation
   4. Southwire Company
   5. Or approved equal

B. Connectors (UL Approved):

   1. Hand-Applied:

      a. T&B "Piggy"
      b. 3M Company "Scotchlok"
      c. Ideal Industries "Wing Nut"
      d. Buchanan "Squeeze On"
      e. Or approved equal

   2. Tool-Applied:

      a. T&B "Stakon" or Series "54475" through "54490"
      b. Ideal Industries "410 Crimp Connector"
      c. Burndy "KA-U" or "YA"
      d. ILSCO "TA", or "AU" or "D"

e. Buchannan "Wrap Cap"
f. Or approved equal

C. Electrical Tape

1. W.H. Brady "B-500+", "B-500"
2. T&B "E-Z" code Type WBC
3. 3M "Scotch 35" vinyl plastic, electrical
4. Johns-Manville
5. Or approved equal

2.2 WIRE AND CABLE

A. General

1. Provide wire with a minimum insulating rating of 600 volts, except for wire used in 50 volts or below applications for control of signal systems, use 300 volt minimum. Where permitted to be incorporated with other wiring systems, 600 volt wire shall be used for lower voltage wiring systems.
2. Conductor construction and application shall comply with N.E.C. article 310.104. Allowable ampacities shall comply with Table 310.15 (B) (16) or other applicable tables based on temperature and location. In general, wire shall be rated 90° C. Use the 75° C column for ampacities. For ambient temperatures other than 30° C, use the proper correction factor listed for each table.

B. Conductor

1. Electrical grade, annealed copper, tinned if rubber insulated and fabricated in accordance with ASTM standards. Minimum size number 12 for branch circuits; number 18 for control wiring.
2. The conductors illustrated on the drawings are copper. Except as otherwise noted, aluminum is not permitted.

C. Stranding and Number of Conductors

1. Number 12 and number 10 conductors shall be solid.
2. Cables larger than number 10, stranded in accordance with ASTM Class B stranding designations.
3. Control wires stranded in accordance with ASTM Class B stranding designations.
4. Cables, multi-conductor unless otherwise noted for low-tension systems.

D. Insulated Single Conductors

1. Type THHN – Flame retardant: Heat resistant thermoplastic insulation, nylon jacket rated for 90 C operation. Use for lighting branch circuit wiring installed and passing through the ballast channels of fluorescent fixtures, wiring in metal roof-decks in or near roof insulation in attic or joist spaces, or in raceways exposed to the sun.
2. Type THWN - 75°C: Use in dry or wet locations.

E. Color Coding

1. Provide consistent color coding of all feeders, sub feeders, motor circuits and the likes as follows:

a. 480/277 volts code

1) Phase A – Brown, Neutral-Gray
2) Phase B – Orange, Ground-Green with Yellow Stripes
3) Phase C - Yellow

b. 208/120 volts code

1) Phase A – Black
2) Phase B – Red
3) Neutral – White
4) Ground – Green

2. Color-code wiring for control systems installed in conjunction with mechanical and/or miscellaneous equipment in accordance with the wiring diagrams furnished with the equipment. Factory color code wire number 2 and smaller. Wire number 1 and larger may be color coded by color taping of the entire length of the exposed ends.

2.3 CONNECTORS

A. Make connections, splices and taps and joints with solderless devices, mechanically and electrically secure. Protect exposed wires and connecting devices with electrical tape or insulation to provide protection not less than that of the conductor.

B. Branch circuit wires (number 10 and smaller):

1. Hand-Applied

a. Coiled, tapered, spring wound devices with a conducting corrosion-resistant coating over the spring steel and a plastic cover and skirt providing full insulation for splice and wired ends. Screw connector on by hand.
b. Hydraulic tool of the same lug manufacturer shall be used and hydraulic tool shall emboss on the connector the proper die number for inspection.

2.4 ELECTRICAL TAPE

A. Specifically designed for use as insulating tape.

2.5 LUBRICANT

A. Use lubricant only where the possibility of damage to conductors exists. Use only a lubricant approved by the cable manufacturer and one, which is compatible with cable and raceways.

PART 3 - EXECUTION

3.1 WIRE AND CABLE

A. Provide a complete system of conductors in raceway system. Mount wiring through a specified raceway regardless of voltage application.

B. Drawings indicate the minimum size wiring for branch circuits. Use No. 12 AWG, minimum, use larger wire sizes for lighting and power branch circuits where indicated on the drawings to allow for voltage drop.

C. Do not install wire in incomplete conduit runs or until after the concrete work and plastering is completed and moisture is swabbed from conduits. Eliminate splices wherever possible. Where necessary, splice in readily accessible pull, junction or outlet box.

D. Flashover or insulation value of joints shall be equal to that of the conductor. Provide Underwriters' Laboratories listed connectors rated to 600 volts for general use.

E. Use terminating fittings, connectors, etc., of a type suitable for the specified cable furnished. Make bends in cable at termination prior to installing compression device. Make fittings tight.

F. Install wire in raceways and make up terminations in accordance with manufacturer's recommendations using special washers, nuts, etc., as required. Use an accepted wire pulling lubricant equivalent to "Yellow" (Ideal) for all wire number 4 and larger. Strip insulation so as to avoid nicking of wire.

G. Extend wire sizing for the entire length of a circuit, feeder, etc. unless specifically noted otherwise.

H. Where multiwire branch circuits (connected to multiple overcurrent devices) are installed in a single conduit, derating adjustments in accordance with NEC 310.15 shall apply. The neutrals shall be counted as current carrying conductors. Up to three single phase circuits may share a common neutral.

I. Where a three phase circuit consisting of (3) three phase wires, (1) one neutral, and (1) one ground wire connected to a single over-current device is installed in a single conduit, derating adjustments outlined in NEC 310.15 shall not apply.

J. Conductors and Insulation Applications

1. Type THWN – THWN Shall be used for all feeders and branch circuits.
2. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway, Armored cable, Type AC Metal-clad cable or Type MC metal clad cable where permitted by N.E.C. articles 320 and 330.
3. Cord Drops and Portable Appliance Connections: Type SO, hard service cord.
4. Fire Alarm Circuits: Type THHN-THWN, in raceway or Power-limited, fire-protective, signaling circuit cable suitable for use in Plenums. Use metal raceways where required in Section 28 31 02 Multiplex Fire Alarm Systems.

5. Class 1 Control Circuits: Type THHN-THWN, in raceway.
6. Class 2 Control Circuits: Type THHN-THWN, in raceway Power-limited cable, concealed in building finishes Power-limited tray cable, in cable tray.
7. Use Type AC/MC cables for fixture whips not to exceed 6 ft. length.
8. The following cable types are not allowed in School Buildings in New York State: NM, NMC, NMS, SE, USE, UF, FC, FCC and TC Cables.

3.2 INSTALLATION

A. General

1. Provide tools, equipment and materials to pull all wire and cable into place and to make required splices and termination.

B. Wire and Cable in Conduit, Duct or Wireway

1. Utilize roller bearing swivel to prevent twisting of cable entering conduit or duct.
2. Take precautions to avoid entrance of dirt and water into conduit and ducts.
3. Clean existing conduits and ducts to remove any pulling compound prior to pulling new cables.
4. Do not damage conductor insulation, braid jacket or sheath.
5. Do not bend conductors to less than manufacturer's recommended radius.
6. Lubricate cable if required for pulling using powdered soapstone or pulling lubricants; do not use oils or greases.
7. Make splices only in pull boxes, junction boxes and outlet boxes.
8. Utilize cable reels on jacks for pulling through pull boxes, ducts and conduits so bends will not be excessive and conductors will not touch sharp edges; use feeding tube where required.
9. For large diameter cables, utilize properly sized pulling grips (open-ended woven basket, two to four feet long, of ductile steel).
10. Do not exceed maximum recommended pulling tension of wire and cable.

C. Splices, Terminations and Connections

1. General: Except where lugs are furnished with equipment, provide terminals and connectors suitable for quantity, conductor size temperature rating and direction of entry (top or bottom).
2. Insulated Flanged Terminals: Install for connection of conductors No. 12 AWG and smaller to device terminals; do not exceed three terminals at single connections.
3. Circumferential Compression Type Connectors: Install for splices and connections No. 4 AWG and larger.

    a. Use for incoming and outgoing cable connections at enclosures and for ground connections.
    b. Use manufacturer's approved tool and correct hex head which embosses die number on connector lug.
    c. Make crimped indentations parallel with conductor.
    d. Fill voids and irregularities with insulation putty.

e. Cover neatly with four (4) layers of vinyl plastic tape except where insulated covers are permitted; half-lap tape in two directions.
f. Use spring-held bakelite covers over splices or taps only with approval of Owner's representative.

4. Conductor Arcproofing

a. Cover two or more power feeder cables occurring in the same switchboard section, junction box or pull box (including pull boxes over switchboards) with arcproof and flameproof tape, except if boxes or compartments are barriered.
b. Provide tape "Scotch" Irvington Tape No. 7700 or Plymouth Rubber Co. Slipknot No. 30 to provide an insulation capable of withstanding a 200-amp arc for not less than 30 seconds.
c. Apply tape in a single layer, half-lapped, or as recommended by the manufacturer to conform to the above requirements. Apply with a random wrap of 1/2 inch (15mm) wide pressure sensitive, plastic film tape color coded as specified in the "conductor identification" paragraph.

D. Wire Marker Identification Labels

1. Utilize labels for all feeders and for those circuits where individual conductor identification is indicated on Drawings.
2. Apply to wires and cables at terminals and in all pull junction and splice boxes.
3. Do not cut and splice multi-conductor control cable for purpose of labeling.
4. Clean surfaces before applying labels.
5. Tag and tape all spare wiring.

3.3 FIELD QUALITY CONTROL

A. Testing

1. Test system wiring for continuity, grounds and short circuits prior to connection of any equipment.
2. Test final equipment connections for proper torque.
3. Insulation Resistance of Feeders and Subfeeders

a. Test with megger for insulation resistance.
b. Locate faults and replace sections found to have faulty insulation.
c. Demonstrate installation is free of grounds and short circuits and that insulation resistance complies with ICEA values.

END OF SECTION 26 05 21

SECTION 26 05 26 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. General: Provide a low impedance grounding system in accordance with the Contract Documents.

1. Purpose of grounding system:

    a. Adequate path for ground fault currents.
    b. Safety to personnel from accidental electric shock hazards.
    c. Prevention of hazardous discharge of static electricity.

2. Whether or not indicated on Drawings, provide continuous ground path for all electrical circuits from point of utilization back to source through ground wires, bonded metallic conduit runs, grounded cable trays, and related items.

B. Electrical Equipment: Provide complete exterior and interior grounding system, including grounding provisions for low voltage switchboard, surge protective devices, motors, emergency generators and other equipment as indicated on Drawings or required by applicable standards.

C. Miscellaneous Equipment: Provide complete grounding for flag poles, metal lighting standards, metal antennas, steel framework of buildings, elevators, and other equipment as indicated on Drawings or required by applicable standards.

D. Related Work Specified in Division 26

1. Section 26 05 10 – Testing, Acceptances and Certifications
2. Section 26 05 14 – Equipment Connections and Coordination
3. Section 26 05 21 –Wires and Cables
4. Section 26 05 33 – Raceways and Boxes
5. Section 26 27 26 – Wiring Devices

E. Related Work Specified in Other Divisions of these Specifications.

1. Concrete
2. Metallic water piping

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. Underwriters Laboratory Standard No. U.L. 467.

2. ANSI C-1 1978
3. IEEE Standards No. 142-1982 and No. 80
4. National Electrical Safety Code
5. NFPA
6. Federal Information Processing Standards, Publication #94

1.3 SUBMITTALS

A. Provide a complete set of shop drawings showing service grounding methods as called for on the Contract Documents.

B. Submit test reports certifying resistance values for buried or driven grounds and water pipe grounds.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Ground Connectors and Clamps; Grounding Bushings and Locknuts.

1. Electrical fitting Corp. (EFCOR)
2. Gedney Electric Company
3. Thomas & Betts
4. Or approved equal

B. Welding Type Ground Connectors:

1. Burndy Engineering Company (Thermoweld)
2. Erico Products, Inc. (Cadweld)
3. Or approved equal

C. Compression Type Grid Connectors:

1. Thomas & Betts Company – Series, 53,000
2. Burndy Corp. – Cat No. YGL-C
3. Or approved equal

D. Ground Rods and Clamps

1. Copperweld Steel Company
2. ITT Blackburn Corp.
3. J.A. Weaver Company
4. Or approved equal

E. Electrical Insulating Tapes:

1. Self-Fusing: 3M Company No. 23

2. Vinyl: 3M Company No. 33+

F. Compound for Compression Connectors:

1. Thomas & Betts Co. – Kopr/Shield
2. Brundy Engineering Company – Penetrox "E"
3. Or approved equal

2.2 MATERIALS

A. Ground Cables: Bare or green color coded, insulated, annealed stranded tinned copper wire as indicated on Drawings; insulated wire to conform to requirements of Section 26 05 21.

B. Mechanical Connectors: Tin-plated aluminum alloy, UL approved and stamped for use with aluminum or copper conductors.

C. Ground Rods:

1. Copper-clad steel fabricated by molten welding process
2. Diameter: 3/4 inch.
3. Length: 10 feet

2.3 GENERAL

A. Furnish and install electrical grounding systems as indicated on the construction documents and as specified herein.

B. Grounding systems shall be installed in accordance with the requirements of the local authorities, NEC Section 250, and subject to the approval of the Architect/Engineer.

C. Install equipment grounding conductors in all feeders and branch circuits.

D. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NEC:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Flexible raceway runs.
6. Armored and metal-clad cable runs.

E. All ground wires and bonding jumpers shall be stranded copper installed in conduit. All ground wires shall be without joints and splices over its entire length.

F. The system neutral shall be grounded at the service entrance only, and kept isolated from grounding systems throughout the building.

G. Each system of continuous metallic piping and ductwork shall be grounded in accordance with the requirements of the NEC Section 250.

H. Mechanical equipment shall be bonded to the building equipment grounding system. This shall include but is not limited to, fans, pumps, chillers, etc.

I. Metallic conduits and portions of metallic piping and duct systems which are isolated by flexible connections, insulated couplings, etc., shall be bonded to the equipment ground with a flexible bonding jumper, or separate grounding conductor.

J. Metal raceways, cable trays, cable armor, cable sheath, enclosures, frames, fittings and other metal noncurrent-carrying parts that are to serve as grounding conductors shall be effectively bonded where necessary to assure electrical continuity and the capacity to conduct safely any fault current likely to be imposed on them. Any non-conductive paint, enamel, or similar coating shall be removed at threads, contact points and contact surfaces or be connected by means of fittings so designed as to make such removal unnecessary.

2.4 RECEPTACLES

A. Receptacles shall be grounded to the outlet box by means of a bonding jumper between the outlet box and the receptacle-grounding terminal.

2.5 MDF/IDF/TELECOM ROOMS

A. In each MDF/Telecom room, provide a 1/4” x 2” x 2 ft. long copper ground bus, wall mounted on stand-offs and located near the main cable entrances. From each ground bus, run a #6 ground wire to the service entrance ground.

2.6 OUTDOOR EQUIPMENT

A. Outdoor enclosures shall be connected with No. 4 bare copper installed not less than 24 inches below grade, connecting to the indicated ground rods or ground grid. Equipment connections shall be bare copper No. 4.

2.7 CONCENTRIC KNOCKOUTS

A. Provide grounding type bushings for conduits terminated through multiple concentric knockouts not fully knocked out, on inside of electrical enclosures. Ground bushing with #12 bare copper to ground bus within enclosure or to enclosure proper where a ground bus is not present.

2.8 TOGGLE SWITCHES

A. Provide grounding clip on each toggle switch. Mount over device mounting strap such that contact is made between mounting strap, screw, faceplate and outlet box.

B. Provide devices with ground screw where required by local authorities and bond this with #10 conductor to associated outlet box.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Ground Conductors:

1. Size as shown on Drawings or as required by NEC Table 250-66 and 250.122.
2. Where ground cables are required, install insulated copper ground conductors in steel conduit, or as indicated.
3. Where ground cable is protected by metallic conduit, bond cable to conduit at both ends.
4. Connect ground conductors in cables and in conduit to appropriate ground buses (as in switchgear, motor control centers, and distribution panelboards) or directly to metallic enclosure if no ground bus is provided.

B. Conduit Attachment to Electrical Equipment:

1. Ground conduits to metal framework of electrical equipment with double locknuts or grounding bushings and bonding jumpers unless otherwise noted.
2. Install bonding jumpers at all electrical equipment to provide continuous ground return path through conduit.
3. Install NEC approved bonding jumpers across expansion fittings between conduit sections for ground path continuity.
4. Bond conduits to cable tray where conduit enters or exits tray.
5. Where motors or other utilization equipment are connected to electrical system with flexible conduit, ground by one of the following:

    a. Flexible metal conduit alone if length is 6 feet or less, conduit is terminated in fitting approved for purpose, and circuit conductors contained therein are protected by overcurrent devices rated 20 at amperes or less.
    b. External jumper across flexible conduit.
    c. Flexible conduit containing integral ground wire.
    d. Do not install external jumpers for flexible conduit connections to kitchen equipment.

C. Wiring Troughs:

1. Use metallic raceway system for principal ground return path, unless otherwise called for on the drawings.
2. Bond wiring troughs containing power circuits and tie to ground bus at switchboards and panelboards; install minimum No. 4/0 AWG copper conductors for bonding between cable system and switchboard ground buses.
3. Apply antioxidant compound to contact surfaces for all bonding connections to cable tray.
4. Install bonding jumpers across hinged joints.

D. Receptacles and Switches:

1. Install bonding jumpers between outlet box and receptacle grounding terminal except where contact device or yoke is provided for grounding purposes.

E. Wireways: Install grounding jumpers for bonding between wireway and other panelboards, conduit, switchboard, and at any other point where solid connection would otherwise not be provided in supporting system to insure continuous ground.

F. Panelboards: Install bonding jumpers inside (if possible) all panelboards to bond feeder conduit to panelboards, except ground panelboards containing branch circuits each having less than 150 amperes current carrying capacity, with two standard locknuts and bushings, one inside and one outside, run up wrench tight.

G. Sheet Metal Boxes:

1. Install bonding jumpers inside (if possible) all sheet metal boxes containing one or more feeders with current carrying capacity of 150 amperes or greater, to bond one conduit with another.
2. Ground boxes containing branch circuits only or feeders each less than 150 amperes current carrying capacity, with two standard locknuts and bushings, one inside and one outside, run up wrench tight.
3. Panelboards: Install bonding in sheet metal boxes in systems over 600 volts, regardless of current carrying capacity.

H. Floor Boxes: Install grounding jumpers where adequate ground connections are not provided through locking screws between high potential power service fittings, cover plates and conduit system.

3.2 FIELD QUALITY CONTROL:

A. Resistance Values for System and Equipment Grounds: For each ground rod and ground grid.

1. Acceptable Testing Equipment: Vibroground by Associated Research, Inc.; or Megger Earth Tester by James G. Biddle Co.
2. Method: Three (3) electrode fall of potential as prescribed by instrument manufacturer.
3. Drive additional ten-foot ground rods spaced eight feet apart, if necessary, until total resistance of system is measured at five ohms or less.

END OF SECTION 26 05 26

SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Shop Drawings: Show support details if different from methods specified or shown on the drawings.

B. Product Data: Catalog sheets, specifications and installation instructions.

PART 2 - PRODUCTS

2.1 ANCHORING DEVICES

A. Sleeve Anchors (FS FF-S-325 Group II, Type 3, Class 3): Molly/Emhart's Parasleeve Series, Phillips' Red Head AN, HN, FS Series, or Ramset's Dynabolt Series.

B. Wedge Anchors (FS FF-S-325 Group II, Type 4, Class 1): Hilti's Kwik Bolt Series, Molly/Emhart's Parabolt Series, Phillips' Red Head WS, or Ramset's Trubolt Series.

C. Self-Drilling Anchors (FS FF-S-325 Group III, Type 1): Phillips' Red Head Series S or Ramset's Ram Drill Series.

D. Non-Drilling Anchors (FS FF-S-325 Group VIII, Type 1): Hilti's Drop-In Anchor Series, Phillips' Red Head J Series, or Ramset's Dynaset Series.

E. Stud Anchors (FS FF-S-325 Group VIII, Type 2): Phillips' Red Head JS Series.

2.2 MISCELLANEOUS FASTENERS

A. Except where shown otherwise on the Drawings, furnish type, size, and grade required for proper installation of the Work, selected from the following: Furnish galvanized fasteners for exterior use, or for items anchored to exterior walls, except where stainless steel is indicated.

1. Standard Bolts and Nuts: ASTM A 307, Grade A, regular hexagon head.
2. Lag Bolts: FS FF-B-561, square head type.
3. Machine Screws: FS FF-S-92, cadmium plated steel.
4. Machine Bolts: FS FF-B-584 heads; FF-N-836 nuts.
5. Wood Screws: FS FF-S-111 flat head carbon steel.
6. Plain Washers: FS FF-W-92, round, general assembly grade carbon steel.
7. Lock Washers: FS FF-W-84, helical spring type carbon steel.
8. Toggle Bolts: Tumble-wing type; FS FF-B-588, type, class and style as required to sustain load.

B. Stainless Steel Fasteners: Type 302 for interior Work; Type 316 for exterior Work; Phillips head screws and bolts for exposed Work unless otherwise specified.

2.3 TPR (THE PEEL RIVET) FASTENERS

A. 1/4 inch diameter, threadless fasteners distributed by Subcon Products, 315 Fairfield Road, Fairfield, NJ 07004 (800) 634-5979.

2.4 POWDER DRIVEN FASTENER SYSTEMS

A. Olin Corp.'s Ramset Fastening Systems, or Phillips Drill Company Inc.'s Red Head Powder Actuated Systems.

2.5 HANGER RODS

A. Mild low carbon steel, unless otherwise specified; fully threaded or threaded each end, with nuts as required to position and lock rod in place. Unless galvanized or cadmium plated, provide a shop coat of red lead or zinc chromate primer paint.

2.6 "C" BEAM CLAMPS

A. With Conduit Hangers:

1. For 1 Inch Conduit Maximum: B-Line Systems Inc.'s BG-8, BP-8 Series, Caddy/Erico Products Inc.'s BC-8P and BC-8PSM Series, or GB Electrical Inc.'s HIT 110-412 Series.
2. For 3 Inch Conduit Maximum: Appleton Electric Co.'s BH-500 Series beam clamp with H50W/B Series hangers, Kindorf's 500 Series beam clamp with 6HO-B Series hanger, or OZ/Gedney Co.'s IS-500 Series beam clamp with H-OWB Series hanger.
3. For 4 Inch Conduit Maximum: Kindorf's E-231 beam clamp and E-234 anchor clip and C-149 series lay-in hanger; Unistrut Corp.'s P2676 beam clamp and P-1659A Series anchor clip with J1205 Series lay in hanger.

B. For Hanger Rods:

1. For 1/4 Inch Hanger Rods: B-Line Systems Inc.'s BC, Caddy/Erico Products Inc.'s BC, GB Electrical Inc.'s HIT 110, Kindorf's 500, 510, or Unistrut Corp.'s P1648S, P2398S, P2675, P2676.
2. For 3/8 Inch Hanger Rods: Caddy/Erico Products Inc.'s BC, Kindorf's 231-3/8, 502, or Unistrut Corp.'s P1649AS, P2401S, P2675, P2676.
3. For 1/2 Inch Rods: Appleton Electric Co. BH-500 Series, Kindorf's 500 Series, 231-1/2, OZ/Gedney Co.'s IS-500 Series, or Unistrut Corp.'s P1650AS, P2403S, P2676.
4. For 5/8 Inch Rods: Unistrut Corp.'s P1651AS beam clamp and P1656A Series anchor clip.

2.7 CHANNEL SUPPORT SYSTEM

A. Channel Material: 12 gage steel.

B. Finishes:

1. Phosphate and baked green enamel/epoxy.
2. Pre-galvanized.
3. Electro-galvanized.
4. Hot dipped galvanized.
5. Polyvinyl chloride (PVC), minimum 15 mils thick.

C. Fittings: Same material and finish as channel.

D. UL Listed Systems:

1. B-Line Systems Inc.'s B-22 (1-5/8 x 1-5/8 inches), B-12 (1-5/8 x 2-7/16 inches), B-11 (1-5/8 x 3-1/4 inches).
2. Grinnell Corp.'s Allied Power-Strut PS 200 (1-5/8 x 1-5/8 inches), PS 150 (1-5/8 x 2-7/16 inches), PS 100 (1-5/8 x 3-1/4 inches).
3. Kindorf's B-900 (1-1/2 x 1-1/2 inches), B-901 (1-1/2 x 1-7/8 inches), B-902 (1-1/2 x 3 inches).
4. Unistrut Corp.'s P-3000 (1-3/8 x 1-5/8 inches), P-5500 (1-5/8 x 2-7/16 inches), P-5000 (1-5/8 x 3-1/4 inches).
5. Versabar Corp.'s VA-1 (1-5/8 x 1-5/8 inches), VA-3 (1-5/8 x 2-1/2 inches).

2.8 MISCELLANEOUS FITTINGS

A. Side Beam Brackets: B-Line Systems Inc.'s B102, B103, B371-2, Kindorf's B-915, or Versabar Corp.'s VF-2305, VF-2507.

B. Pipe Straps:

1. Two Hole Steel Conduit Straps: B-Line Systems Inc.'s B-2100 Series, Kindorf's C-144 Series, or Unistrut Corp.'s P-2558 Series.
2. One Hole Malleable Iron Clamps: Kindorf's HS-400 Series, or OZ/ Gedney Co.'s 14-G Series, 15-G Series (EMT).

C. Deck Clamps: Caddy/Erico Products Inc.'s DH-4-T1 Series.

D. Fixture Stud and Strap: OZ/Gedney Co.'s SL-134, or Steel City's FE-431.

E. Supporting Fittings for Pendent Mounted Industrial Type Fixtures on Exposed Conduit System:

1. Ball Hanger: Appleton Electric Co.'s AL Series, or Crouse-Hinds Co.'s AL Series.
2. Flexible Fixture Hanger: Appleton Electric Co.'s UNJ-50, UNJ-75, or Crouse-Hinds Co.'s UNJ115.
3. Flexible (Hook Type) Fixture Hanger: Appleton Electric Co.'s FHHF, or Crouse-Hinds Co.'s UNH-1.

4. Eyelet: Unistrut Corp.'s M2250.
5. Eyelet with Stud: Kindorf's H262, or Unistrut Corp.'s M2350.
6. Conduit Hook: Appleton Electric Co.'s FHSN, or Crouse-Hinds Co.'s UNH-13.

F. Supporting Fasteners (Metal Stud Construction): Metal stud supports, clips and accessories as produced by Caddy/Erico Products Inc.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Where specific fasteners are not specified or indicated for securing items to in-place construction, provide appropriate type, size, and number of fasteners for a secure, rigid installation.

B. Install anchoring devices and other fasteners in accordance with manufacturer's printed instructions.

C. Make attachments to structural steel wherever possible.

3.2 FASTENER SCHEDULE

A. Material:

1. Use cadmium or zinc coated anchors and fasteners in dry locations.
2. Use hot dipped galvanized or stainless steel anchors and fasteners in damp and wet locations.
3. For corrosive atmospheres or other extreme environmental conditions, use fasteners made of materials suitable for the conditions.

B. Types and Use: Unless otherwise specified or indicated use:

1. Anchoring devices to fasten items to solid masonry and concrete when the anchor is not subjected to pull out loads, or vibration in shear loads.
2. Toggle bolts to fasten items to hollow masonry and stud partitions.
3. TPR fasteners to fasten items to plywood backed gypsum board ceilings.
4. Metallic fasteners installed with electrically operated or powder driven tools for approved applications, except:

   a. Do not use powder driven drive pins or expansion nails.
   b. Do not attach powder driven or welded studs to structural steel less than 3/16 inch thick.
   c. Do not support a load, in excess of 250 lbs. from any single welded or powder driven stud.
   d. Do not use powder driven fasteners in precast concrete.

3.3 ATTACHMENT SCHEDULE

A. General: Make attachments to structural steel or steel bar joists wherever possible. Provide intermediate structural steel members where required by support spacing. Select steel members for use as intermediate supports based on a minimum safety factor of 5.

1. Make attachments to steel bar joists at panel points of joists.
2. Do not drill holes in main structural steel members.
3. Use "C" beam clamps for attachment to steel beams.

B. Where it is not possible to make attachments to structural steel or steel bar joists, use the following methods of attachment to suit type of construction unless otherwise specified or indicated on the drawings:

1. Attachment to Steel Roof Decking (No Concrete Fill):

    a. Decking With Hanger Tabs: Use deck clamps.
    b. Decking Without Hanger Tabs:

        1) Before Roofing Has Been Applied: Use 3/8 inch threaded steel rod welded to a 4 x 4 x 1/4 inch steel plate and installed through 1/2 inch hole in roof deck.
        2) After Roofing Has Been Applied: Use welding studs, or self-drilling/tapping fasteners. Exercise extreme care when installing fasteners to avoid damage to roofing.

2. Attachment to Concrete Filled Steel Decks (Total thickness, 2-1/2 inches or more):

    a. Before Fill Has Been Placed:

        1) Use thru-bolts and fish plates.
        2) Use welded studs. Do not support a load in excess of 250 pounds from a single welded stud.

    b. After Fill Has Been Placed: Use welded studs. Do not support a load in excess of 250 lbs from a single welded stud.

3. Attachment to Cast-In-Place Concrete:

    a. Fresh Concrete: Use cast-in-place concrete inserts.

4. Attachment to Hollow Block or Tile Filled Concrete Deck:

    a. New Construction: Use cast-in-place concrete inserts by having Construction Work Contractor omitting blocks and pouring solid blocks with insert where required.

5. Attachment to Metal Stud Construction: Use supporting fasteners manufactured specifically for the attachment of raceways and boxes to metal stud construction.

   a. Support and attach outlet boxes so that they cannot torque/twist. Either:

      1) Use bar hanger assembly, or:
      2) In addition to attachment to the stud, also provide far side box support.

3.4 CONDUIT SUPPORT SCHEDULE

A. Use pipe straps and specified method of attachment where conduit is installed proximate to surface of wood or masonry construction.

   1. Use hangers secured to surface with specified method of attachment where conduit is suspended from the surface.

B. Use "C" beam clamps and hangers where conduit is supported from steel beams.

C. Use deck clamps and hangers where conduit is supported from steel decking having hanger tabs.

   1. Where conduit is supported from steel decking which does not have hanger tabs, use clamps and hangers secured to decking, utilizing specified method of attachment.

D. Use channel support system supported from structural steel for multiple parallel conduit runs.

E. Where conduits are installed above ceiling, do not rest conduit directly on runner bars, T-Bars, etc.

   1. Conduit Sizes 2-1/2 Inches and Smaller: Support conduit from ceiling supports or from construction above ceiling.
   2. Conduit Sizes Over 2-1/2 Inches: Support conduit from beams, joists, or trusses above ceiling.

3.5 LIGHTING FIXTURE SUPPORT SCHEDULE

A. General: Do not support fixtures from ceilings or ceiling supports unless it is specified or indicated on the drawings to do so.

   1. Support fixtures with hanger rods attached to beams, joists, or trusses. Hanger rod diameter, largest standard size that will fit in mounting holes of fixture.

      a. Where approved, channel supports may span and rest upon the lower chord of trusses and be utilized for the support of lighting fixtures.
      b. Where approved, channel supports may span and be attached to the underside of beams, joists, or trusses and be utilized for the support of lighting fixtures.

2. Use 2 nuts and 2 washers on lower end of each hanger rod to hold and adjust fixture (one nut and washer above top of fixture housing, one nut and washer below top of fixture housing).

   a. Where specified that an adequately supported outlet box is to support a fixture or be utilized as one point of support, support the box so that it may be adjusted to bring the face of the outlet box even with surface of ceiling.

B. Number of Supports for Ceiling Mounted Lighting Fixtures: Provide at least the following number of supports. Provide additional supports when recommended by fixture manufacturer, or shown on the drawings.

1. Commercial and Industrial Fixtures:

   a. Support individual fixtures less than 2 feet wide at 2 points.
   b. Support continuous row fixtures less than 2 feet wide at points equal to the number of fixtures plus one. Uniformly distribute the points of support over the row of fixtures.
   c. Support individual fixtures 2 feet or wider at 4 corners.
   d. Support continuous row fixtures 2 feet or wider at points equal to twice the number of fixtures plus 2. Uniformly distribute the points of support over the row of fixtures.
   e. An adequately supported outlet box may be utilized as one point of support for fixtures weighing less than 50 pounds.

3.6 CHANNEL SUPPORT SYSTEM SCHEDULE

A. Use channel support system where specified or indicated on the drawings.

B. Channel supports may be used, as approved, to accommodate mounting of equipment.

C. Material and Finish:

1. Dry Locations: Use 12 gage steel channel support system having any one of the specified finishes.
2. Damp Locations: Use 12 gage steel channel support system having any one of the specified finishes except green epoxy/enamel.
3. Wet Locations: Use 12 gage steel channel support system having hot dipped galvanized, or PVC finish.

END OF SECTION 26 05 29

SECTION 26 05 33 - RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 SUMMARY

A. Provide raceways in accordance with the Contract Documents.

B. Related work in other sections:

1. Section 26 05 00 – Common Work Results for Electrical
2. Section 26 05 15 – Ceiling, Floor, and Wall Electrical Penetration Fire Seals
3. Section 26 05 26 – Grounding and Bonding
4. Section 26 05 29 – Hangers and Supports for Electrical Systems
5. Section 26 05 53 – Identifications for Electrical Systems
6. Section 26 27 26 – Wiring Devices

1.2 REFERENCES

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. Rigid Steel Conduit

   a. UL Standards UL-6
   b. A.N.S.I. C80-1
   c. Federal Specification WW-C-581E

2. Intermediate Metallic Conduit

   a. UL Standard UL-1242
   b. Federal Specification WW-C-581E

3. Electrical Metallic Tubing

   a. UL Standard UL-797
   b. A.N.S.I. C80-3
   c. Federal Specification WW-C-563

4. Flexible Steel Conduit

   a. UL Standard UL-1

5. Liquid Tight Flexible Conduit

   a. UL Standard UL-360

6. Non-Metallic Conduit

   a. UL Standard UL-651
   b. A.N.S.I. Standard F512
   c. N.E.M.A. Standard TC-2
   d. Federal Specification GSA-FSS and W-C-1094-A
   e. Corps of Engineers Specification CE-303:01

7. Wireways and Auxiliary Gutters

   a. UL Standard UL-870

1.3 SUBMITTALS

A. Provide listing of proposed manufacturers.

B. Provide manufacturer's catalog cuts of fittings.

C. Where wireways and/or auxiliary gutters are employed full erection drawings must be submitted. Drawings to include plan views, elevations, size of wireways, type and quantity of conductors, proposed to be installed therein, etc.

D. Submit shop drawings or catalog descriptive data on boxes exceeding twenty-four (24") inches for any one dimension.

E. Submit shop drawings or catalog descriptive for floor boxes and accessories.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. Conduit Bodies:

   1. Appleton Electric Co.
   2. Crouse-Hinds Division, Cooper Industries, Inc.
   3. Killark Electric Mfg. Co.
   4. Or approved equal

C. Fittings:

   1. Appleton Electric Co.
   2. O-Z/Gedney
   3. Thomas and Betts
   4. Or approved equal

D. Wireway:

1. GS Metals Corp.
2. Hoffman Engineering Co.
3. Keystone/Rees, Inc.
4. Square D Co.
5. Or approved equal

E. Surface Metal Raceway:

1. GS Metals Corp.
2. Square D Co.
3. The Wiremold Co.
4. Or approved equal

2.2 RACEWAY TYPES

A. Standard Threaded Rigid Steel Conduit

1. Rigid conduit, heavy wall, galvanized.
2. Threaded type fittings: "Erickson" couplings where threaded cannot be used.

B. Intermediate Metallic Conduit

1. Light weight, rigid steel conduit, galvanized.
2. Threaded type fittings: "Erickson" couplings where threaded cannot be used.

C. Electric Metallic Tubing

1. Continuous, seamless tubing, galvanized or sheradized on the exterior, coated on the interior with a smooth hard finish of lacquer, varnish, or enamel.
2. All couplings, connectors, etc., used in conjunction with this raceway, which are two (2") inches in size and smaller shall be steel compression gland fittings, "Tomic" tap-on or "Tomic" compression type. Conduits 2 1/2 inch size and larger may use set screw type which employ four (4) set screws per fitting.
3. EMT is not allowed in concrete.

D. Flexible Steel Conduit

1. Single strip, continuous, flexible interlocked, double-wrapped steel, galvanized inside and outside, forming smooth internal wiring channel.
2. Maximum length: Six (6) feet.
3. Each section of raceway must contain a bonding wire at each end and sized as required. Provide connectors with insulating bushings.
4. Squeeze-type fittings.

E. Liquid Tight Flexible Electrical Conduit

1. Same as flexible steel conduit except with tough, water-tight plastic outer jacket.

2. Fittings: Cast malleable iron body and gland nut, cadmium plated with one-piece brass grounding bushings which thread to interior of conduit. Spiral molded vinyl sealing ring between gland nut and bushing and nylon insulated throat.

F. Non-Metallic Raceway

1. Composed of polyvinyl chloride suitable for 90 degrees C.
2. Raceway, fittings, and cement must be produced by the same manufacturer who must have had a minimum of ten (10) years experience in manufacturing the products.
3. Materials must have a tensile strength of 7,000-7,200 psi at 73.4 degrees F, flexural strength of 12,000 psi and compressive strength of 9,000 psi.
4. All joints shall be solvent cemented in accordance with the recommendations of the manufacturer.

G. Wireways and Auxiliary Gutters

1. Of sizes and shapes indicated on the drawings and as required.
2. Provide all necessary elbows, tees, connectors, adaptors, etc.
3. Hinged cover secured with captive screws.
4. Wire retainers not less than twelve (12") inches on center.

2.3 OUTLET, JUNCTION, AND PULL BOXES

A. Cast Type Conduit Boxes, Outlet Bodies and Fittings

1. Provide surface mounted outlet and junction boxes, in indoor locations, where exposed to moisture and all outdoor locations.
2. Requirements:

Type Conduit	Box Material	Type Hubs
Rigid Steel & IMC	Ferrous Alloy	Inside Thread
Electrical Metallic Tubing	Ferrous Alloy or Inside Thread with Adapter	Compression

3. Covers: Cast or sheet metal unless otherwise required.
4. Tapered threads for hubs.

B. Galvanized Pressed Steel Outlet Boxes

1. General

a. Pressed steel galvanized or cadmium-plated, minimum of four (4") inches octagonal or square, with galvanized cover or extension ring as required.

2. Concrete Box

a. Four (4") inch octagons with a removable backplate and 3/8" fixture stud, if required. Depth of box shall allow for a minimum of one (1") inch of concrete to be poured above the backplate.

3. Switch and Receptacle Box, Indoors

   a. Nominal four (4") inches square, 1-1/2" or 2-1/8" deep as required, with adaptor covers as required unless otherwise indicated on drawings.

4. Lighting Fixture Box

   a. Four (4") inch octagon with 3/8" fixture stud.
   b. For suspended ceiling work, four (4") inch octagon with removable backplate where required, and two (2) parallel bars for securing to the cross-furring channels and extend flexible conduit to each fixture.

5. Plug any open knockouts not utilized.

C. Sheet Steel Boxes Indoors

1. No. 12 USS gauge sheet steel for boxes with maximum side less than forty (40") inches, and maximum area not exceeding 1,000 square inches; riveted or welded 3/4 inch flanges at exterior corners.
2. No. 10 USS gauge sheet steel for boxes with maximum side forty (40") to sixty (60") inches, and maximum area 1,000 to 1,500 square inches; riveted or welded 3/4 inch flanges at exterior corners.
3. No. 10 USS gauge sheet steel riveted or welded to 1-1/2" by 1-1/2" by 1/4" welded angle iron framework for boxes with a maximum side exceeding sixty (60") inches and more than 1,500 square inches in area.
4. Covers

   a. Same gauge steel as box.
   b. Subdivided single covers so no section of cover exceeds fifty (50) pounds.
   c. Machine bolts, machine screws threaded into tapped holes, or sheet metal screws as required; maximum spacing twelve (12") inches.

5. Paint

   a. Rust inhibiting primer; ANSI No. 61 light gray finish coat.

6. Where size of box is not indicated, size to permit pulling, racking and splicing of cables.

D. Pull and Splice Boxes, Outdoors

1. Aluminum reinforced, with removable covers secured by brass machine screws.
2. Where size of box is not indicated, size to permit pulling, racking, and splicing of the cables.
3. Braze a ground connector suitable for copper cables to the inside of the box.

E. Identification Labels

1. Acceptable Manufacturers

   a. W.H. Brady Company (Style A)

b. Thomas & Betts Company (T&B), Style A

2. Plasticized Cloth

   a. Non-conductive
   b. Waterproof
   c. Capable of withstanding continuous temperatures of 235 degrees F and intermittent temperatures to 300 degrees F.
   d. Over-coating for protection against oil, solvents, chemicals, moisture, abrasion and dirt.

3. Heavy, thermo-resistant industrial grade adhesive, for adhesion of label to any surface without curling, peeling or falling off.

4. Legends

   a. Sharp, bold face, two-inch black letters on "Alert" orange background.

5. Label Designations: Nominal System Voltages Applied to the covers of all low voltage pull, splice and junction boxes.

PART 3 - EXECUTION

3.1 APPLICATION OF RACEWAYS

A. The following applications must be adhered to except as otherwise required by Code. Raceways not conforming to this listing must be removed by this Contractor and replaced with the specified material at this Contractor's expense.

B.

Raceway Types	Application
Rigid Steel	Application: Where installed in concrete within the building, in or under slabs within the building, where exposed to mechanical injury, where specifically required, indoors where exposed to moisture and where required by codes and for all circuits in excess of 600 volts.
I.M.C.	Application: Same as standard threaded rigid steel conduit.
E.M.T.	Application: Use in every instance except where another material is specified. Strictly prohibited in concrete or in contact with earth or fill.
Flexible Steel	Applications: Use in dry areas for connections to lighting fixtures in hung ceilings, connections to equipment installed in removable panels of hung ceilings at bus duct takeoffs, at all transformer or equipment raceway connections where sound and vibration isolation is required. Maximum length: 6'-0".

Liquid-Tight Flexible Conduit	Applications: Use in areas subject to moisture where flexible metal conduit is permitted, at connections to all motors.

3.2 RACEWAY SYSTEM IN GENERAL

A. Provide raceways for all wiring systems. All wiring shall be installed in EMT unless otherwise noted or required by Code. Emergency system wiring must be kept independent of the normal system wiring. Where non-metallic raceways are utilized, provide sizes as required with the grounding conductor considered as an insulated additional conductor. Minimum size, 3/4 inch for branch circuits, and one (1") inch minimum for feeders. Wiring of each type and system must be installed in separate raceways.

B. Install capped bushings on raceways as soon as installed and remove only when wires are pulled. Securely tie embedded raceway in place prior to embedment. Raceways installed below or in floor slabs must extend a minimum of four (4") inches above the finished slab to the first connector. Lay out the work in advance to avoid excessive concentrations of multiple raceway runs.

C. Locate raceways so that the strength of structural members is unaffected and they do not conflict with the services of other trades. Install one (1") inch or larger raceways, in or through structural members (beams, slabs, etc.) only when and in the manner accepted by the Architect/Engineer. Draw up couplings and fittings full and tight. Protect threads from corrosion with one (1) coat red lead or zinc chromate after installation.

D. Above Grade-Defined as the area above finished grade for a building exterior and above top surface of any slabs (or other concrete work) on grade for a building interior. Above-grade raceways shall comply with the following:

1. Install raceways concealed except at surface cabinets and for motor and equipment connection in electrical and mechanical rooms. Install a minimum of six (6") inches from flues, steam pipes, or other heated lines.
   Provide flashing and counter-flashing for waterproofing of raceways, outlets, fittings, etc., which penetrate the roof. Route exposed raceways parallel or perpendicular to building lines with right-angle turns and symmetrical bends. Run raceways in or under slabs in a direct line and, where possible, with long sweep bends and offsets. Provide sleeves in forms for new concrete walls, floor slabs, and partitions for passage of raceways. Waterproof sleeved raceways where required.
2. Provide raceway expansion joints for exposed and concealed raceways with necessary bonding conductor at building expansion joints and between buildings or structures and where required to compensate for raceway or building thermal expansion and contraction. Provide expansion fittings every 200 feet on outdoor conduit.
3. Provide one (1) empty 3/4 inch raceway for each three (3) spare unused poles or spaces of each flush-mounted panelboard. Terminate empty 3/4 inch conduit in a junction box, which after completion, is accessible to facilitate future branch circuit extension.
4. Provide raceway installation (with appropriate seal-offs, explosion-proof fittings, etc.) in special occupancy area, as required. Provide conduit seal-offs where portions of an interior raceway system pass through walls, ceiling, or floors which separate adjacent

rooms having substantially different maintained temperatures, as in refrigeration or cold storage rooms.

5. Protect metal raceways in earth or fill with two (2) coats of asphalt base paint. Touch up abrasions and wrench marks after conduit is in place.
6. In lieu of the above, protect raceways with a minimum of twenty (20) mil tape approved for the purpose and overlapped a minimum of one half tape width.
7. Provide drag wire in spare or empty raceways. Allow five (5) feet of slack at each end and in each pull box. Tag both ends of wire denoting opposite end termination location with black India ink on flameproof linen tag.
8. Install pull-wire in empty raceways. Use polypropelene on monofilament plastic line with not less than 200 lb. tensile strength. Leave at least 12 inches of slack at each end of pull-wire. Conduits designated as “spare” shall be capped.
9. All conduits stubbed above the floor for voice/data or signal systems in the main electrical room shall be stubbed 6” AFF and provided with insulating bushings.

E. Raceways in hung ceiling shall be run on and secured to slab or primary structural members of ceiling, not to lathing channels or T-bars, Z-bars, or other elements which are the direct supports of the ceiling panels. Secure conduit firmly to steel by clips and fittings designed for that purpose. Install as high as possible, but not less than 1'-0" above hung ceilings.

F. Conduit above accessible ceilings and exposed raceways shall be run parallel or at right angles with building lines. Secure raceway clamps or supports to masonry materials by toggle bolts, expansion bolts, or steel inserts. Install raceways on steel construction with approved clamps which do not depend on friction or set screw pressure alone.

G. Clear raceway of all obstructions and dirt prior to pulling in wires or cables. This shall be done with a ball mandrel (diameter approximately 85% of conduit inside diameter) followed by a close fitting wire brush and wad of felt, or similar material. This assembly may be pulled in together with, but ahead of, the cable being installed. All empty raceways shall be similarly cleaned. Clear any raceway which rejects ball mandrel.

H. Support less than two (2") inches trade size, vertically run, raceways at intervals no greater than eight (8) feet. Support such raceways, two (2") inches trade size or larger and made up with threaded couplings, at intervals no greater than the story height, or fifteen (15) feet, whichever is smaller.

I. Support less than (1") inch trade size, horizontally run, raceways at intervals no greater than seven (7) feet. Support such raceways, one (1") inch trade size or larger, at intervals no greater than ten (10) feet.

3.3 WIREWAYS AND AUXILIARY GUTTER

A. Wireways installed in hung ceilings shall be placed such that the cover will hinge upward from the side.

B. Twelve (12") inches clear shall be provided from wireway cover when it is in the open position.

C. Routing of wireways, shown on plans, is diagrammatic. Provide a complete system including corners, elbows, and angle sections to clear the work of other trades and other obstructions.

3.4 OUTLET, JUNCTION, AND PULLBOXES

A. Provide outlet, junction, and pullboxes as indicated on the drawings and as required for the complete installation of the various electrical systems, and to facilitate proper pulling of wires and cables. J-boxes and pullboxes shall be sized per electrical code minimum. Boxes on empty conduit systems shall be sized as if containing conductors of #4 AWG.

B. The exact location of outlets and equipment is governed by structural conditions and obstructions, or other equipment items. When necessary, relocate outlets so that when fixtures or equipment are installed, they will be symmetrically located according to the room layout and will not interfere with other work or equipment. Verify final location of outlets, panels, equipment, etc., with Architect.

C. Back-to-back outlets in the same wall, or "thru-wall" type boxes, are not permitted. Provide twelve (12") inch (minimum) spacing for outlets shown on opposite sides of a common wall to minimize sound transmission.

D. Fit outlet boxes in finished ceiling or walls with appropriate covers, set flush with the finished surface. Where more than one switch or device is located at one point, use gang boxes and covers unless otherwise indicated. Sectional switch boxes or utility boxes will not be permitted. Provide Series "GW" (Steel City) tile box, or as accepted, or a four (4") inch square box with tile ring in masonry walls, which will not be plastered or furred. Where drywall materials are utilized, provide plaster ring. Provide outlet boxes of the type and size suitable for the specific application.

E. Pull Box Spacing

1. Provide pull boxes so no individual conduit run contains more than the equivalent of four (4) quarter bends (360 degrees total).
2. Conduit Sizes 1-1/4" and larger.

    a. Provide boxes to prevent cable or wire from being excessively twisted, stretched, or flexed during installation.
    b. Provide boxes for medium voltage cables so that maximum pulling tensions do not exceed cable manufacturer's recommendations.
    c. Provide support racks for boxes with multiple sets of conductors so that the conductors do not rest on any metal work inside box.

3. Conduit sizes one (1") inch and smaller, low voltage wire and cable (maximum distances).

    a. 150 feet straight runs.
    b. 100 feet runs with one 90 degree bend or equivalent.
    c. 75 feet runs with two 90 degree bends or equivalent.
    d. 50 feet runs with three or four 90 degree bends or equivalent.

F. Sheet Steel Boxes

1. Size and shape (if not on drawings) to avoid exceeding manufacturer's minimum bending radius recommendations for conductors.

2. Access for removal and replacement of conductors, splices, and equipment.
3. Minimum dimensions of boxes in runs of 1-1/2" or larger conduit.

   a. Straight Pulls

      1) Sizes length eight (8) times nominal diameter of largest conduit.

   b. Angle or U Pulls

      1) Size such that distance between conduit entry and opposite wall of box is six (6) times nominal diameter of largest conduit.

4. Covers

   a. Fasten to flange or framework of box with machine bolts, machine screws threaded into tapped holes, or sheet metal screws as required.

G. Identification labels for all low voltage and medium voltage pull, splice and junction boxes in main feeder and subfeeder runs, indicating nominal system voltage.

1. Apply labels after painting of boxes, conduits, and surrounding areas have been completed.
2. Clean surfaces before applying labels; clean aluminum surfaces with solvent wipe.
3. Apply labels on cover and minimum of one (1) fixed side: one (1) label viable from floor where boxes are installed exposed.

3.5 SLEEVES

A. Where sleeves are required for the installation of electrical work, passing through walls or floors, they shall be furnished and installed under this Section of the specification unless indicated otherwise on the drawings. Such sleeves shall be galvanized or black enameled rigid steel conduit or Schedule 40 black steel pipe. Aluminum conduit sleeves shall not be used. Where specific sizes are not indicated on the drawings, sleeves shall be sized to provide 1/2 inch clearance around the outside surface of the item for which they are installed. They shall be cut flush with wall surfaces and shall extend two (2") inches above finished floor level, or as indicated on the drawings.

B. For interior walls and for floors, the space between conduit, ground cable, or similar items and sleeves shall be packed to the full depth of wall or slab thickness with products manufactured by HILTI or equal:

END OF SECTION 26 05 33

SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide fixed identification of all distribution equipment and conductors in accordance with the Contract Documents.

B. Related work in other sections:

1. Section 26 05 21 – Wires and Cables
2. Section 26 24 13 – Switchboards
3. Section 26 24 16 – Panelboards
4. Section 26 28 23 – Disconnect Switches – Fused and Non-Fused
5. Section 26 29 13 – Enclosed Controllers
6. Section 26 51 00 – Interior Lighting

1.2 REFERENCES

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. Industry standards shall apply.

1.3 SUBMITTALS

A. Identification procedures shall be noted and scheduled on the applicable shop drawings.

PART 2 - PRODUCTS

2.1 Unless otherwise noted, nameplates shall be black lamacoid plates with white engraved upper case letters enclosed by white border on beveled edge.

2.2 Nameplates for equipment, supplied by the emergency system, shall be red lamacoid with white lettering.

2.3 All nameplates must be engraved and must be secured with rivets, brass or cadmium plate screws. The use of Dymo tape or the like is unacceptable.

2.4 Lettering heights unless otherwise noted must be as follows:

Item	Lettering Height
Panelboards	1/2"
Feeder Switches	1/4"
Remote Smoke Detector Lamps	1/8"
Wall Plates	1/8"
Motor Controllers	1/4"
Fire Alarm Control Panels	1/2"

2.5 Cable tags must be flameproof secured with flameproof non-metallic cord.

2.6 Nameplate inscriptions must bear the name and number of equipment to which they are attached as indicated on the Drawings. The engineer reserves the right to make modifications in the inscriptions as necessary.

2.7 The Engineer reserves the right to request additional nameplates at time of review of shop drawings and upon site observations. These shall be furnished at no additional cost to the Owner.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Panelboards

1. Furnish and install a nameplate for each panelboard and load center engraved with the identification indicated on the Drawings. Mount at top of panel.
2. After installations are complete, provide and mount under sturdy transparent shield in the directory frame of each panel door, a neat, accurate, and carefully typed directory properly identifying the lighting, receptacles, outlets and equipment each overcurrent device controls.
3. Include on directory the panel or load center identification, the cable and raceway size of panel feeder, and the feeder origination point.

B. Disconnect Switches

1. Furnish and install a nameplate for each disconnect switch engraved with the equipment designation which the disconnect serves.

C. Motor Controllers

1. Furnish and install a nameplate for each motor controller or combination motor controller for both individual motor controllers and those in a motor control center, etc. Engraving must indicate the motor served and the type of service (e.g., AC-8 – 1st floor supply, EF-2 electric closet exhaust).

D. Feeder Switches

1. Furnish and install for each circuit breaker a nameplates with the following:

   a. Indicate the load served, the size and type of cable and raceway example:

      1) LP-4, LP-5, LP-6
      2) 4#500 MCM-THW-CU-3-1/2"C

E. Remote Smoke Detector Lamps and Test Stations

1. Furnish and install a nameplate on each remote smoke detector lamp and/or test station. Engraving must indicate the location of the devise to which the lamp is connected, as approved by the Engineer.

F. Switches

1. Furnish and install an engraved nameplate for each switch, controlling loads which are not local to the switch. Engraving shall be as directed by the Engineer.

G. Pullboxes, Enclosures and Cable Terminations

1. Furnish and install cable tags on each cable, which enters a pullbox, enclosure, switchboard, and at terminations. Mark tags with type written inscription noting the load served, type and size of cable, and the overcurrent device protecting the cable.

H. Fire Alarm Control Panels

1. Furnish and install on each fire alarm terminal cabinet an approved nameplate.
2. Nameplates shall indicate floor and where multiple panels cabinets are installed a prime designation for each cabinet (e.g. FATC-1A, FATC-1B).

I. Capping and Staking

1. Wherever raceways are for future use and are terminated outside of the structure, stake the location with a 2'-0" long, 1" x 1" wooden stake having a conspicuous colored flag.
2. Provide metal markers inserted into 8" D x 12" concrete ballast at all raceway terminations exterior to the structure. Inserts must state the date the raceway was installed, the size of the raceway, and the point of the raceway termination.

J. Generator Control Panel

1. Furnish and install a red nameplate for each generator control panel. Engraving shall indicate the generator controlled by the panel.

K. Painting and Finishing

1. All electrical fitting, supports, hanger rods, pullboxes, channel frames, conduit racks, outlet boxes, brackets clamps, etc., shall be galvanized finished or have enamel paint finish over corrosion-resistant primer.
2. All panelboards, etc., shall be factory finished in alkyd high gloss enamel applied over corrosion-resistant primer. Matte or flat type finish paint not acceptable. Factory finished units that are scratched or marked during installation shipping shall be touched up with matching spray-on air dry lacquer or, if required, to provide a satisfactory job, shall be completely refinished.
3. Fire alarm pullboxes and junction boxes to be finished in red.
4. Telecommunications terminal panel and junction boxes to be finished in yellow.
5. Low voltage switching terminal cabinets and pullboxes to be finished in black.
6. Security terminal panel and junction boxes to be finished in yellow.

END OF SECTION 26 05 53

SECTION 26 07 00 - ELECTRICAL DEMOLITION

PART 1 - GENERAL

1.1 GENERAL

A. The work of this section includes furnishing of all labor, tools, materials, and equipment necessary to complete all the demolition required for the project as specified herein and shown on the drawings.

B. Cooperation with contractors under separate contracts is required, and the work described herein and shown on the drawings shall be coordinated as required to fulfill the intent of the contract.

1.2 INTENT

A. It is the intent of this specification and accompanying drawings to describe and indicate the demolition work to be performed. It is not intended that the specifications and drawings describe and indicate every piece of equipment required to be removed for where items are intended to be removed or as required for the satisfactory completion of the project or is considered to be the accepted practice of the trade, they shall be considered to be specified and indicated.

B. The contractor shall disconnect and remove all lighting fixtures, conduit, wire and related electrical items as indicated on the drawings, or as required by the project. This includes all abandoned low voltage signal and communication cables.

C. The contractor shall seal floor, wall and ceiling openings with thermo setting fire resistive compound after removal of conduits.

D. The contractor is cautioned that when performing demolition work circuitry servicing areas of the building outside the work area must remain in operation. The contractor is responsible, at his own expense, to repair any services or damages caused by his demolition work.

E. When disconnecting equipment from existing circuits, if equipment is connected to the circuit which must remain active, the circuit continuity shall be maintained as required. Wiring from circuits becoming completely inactive shall be removed back to the source of supply.

PART 2 - SCOPE OF WORK

2.1 DEMOLITION/ALTERATION

A. Prior to start of demolition, check to determine that power, communication services, etc., such as electricity and telephone in the work area, have been disconnected at the source of supply.

B. The Contractor shall furnish and erect barriers, and maintain approved danger, warning, and "Keep Out" signs at locations where the placing of such signs is warranted for safety of all personnel not working in this area.

C. Demolition shall be performed in such a manner as to avoid hazards to persons and property, interference with the use of adjacent properties, and interruption of free passage to and from such property. Work shall be performed in strict accordance with all Municipal, State and Federal Rules, Regulations, Codes, and Laws which may govern and apply to this work.

D. During the demolition work in the effected areas, the building non-work areas must be protected from dust, dirt and possible water damage, to the Owner's satisfaction.

E. All areas shall be cleaned and free of all debris resulting from the demolition work on a daily basis.

F. Remove all equipment shown to be removed; however, all changes cannot be detailed completely on the drawings, some removals and relocations of existing electric work will be necessary for satisfactory performance of this and other trades. Take into consideration in proposal all required changes.

G. Maintain continuous service on feeders, circuits or partial circuits, and outlets affected by this work, except where Architect gives written permission for outage for specified time. All work requiring shut down of existing systems shall be performed on overtime at hours as approved by the Architect and at no additional cost to the Owner. Submit schedule of required outages to the Owner for approval. Perform work in a manner to minimize shutdown time.

H. Provide reconnections and temporary installations as required; remove at job completion.

I. Take possession and remove from the premises all abandoned materials and equipment unless specified as returnable to the Owner; in which case, remove without damage all such equipment and turn over and deliver to Owner at location designated by the Owner.

J. Cut back to floor, wall, or ceiling and plug ends of concealed conduits made obsolete by alterations to permit refinishing surfaces. Remove exposed conduits, wireways, outlet boxes, hangers and devices made obsolete by this work unless designated specifically to remain.

K. Existing concealed conduits not interfering with the work of this or any other trade may remain; however, wiring shall be removed from panelboards or source of power and ends taped. No unused live wiring shall be left in place.

L. Provide blank plates on all unused outlet boxes that are unable to be removed.

M. Wherever extensions of wires or cables are shown on the drawings, check and verify wire and cable sizes and capacities. Secure Architect's acceptance of this data before new cables are ordered or installation started.

N. Remove all unused data/voice/TV cables installed above existing ceilings.

PART 3 - SALVAGE

3.1 SALVAGE

A. The contractor shall be responsible for all damage to existing materials not affected by the demolition work. The contractor shall repair or replace damaged material or equipment as directed at no additional cost to the owner. Repairing and patching of areas shall be done by the respective trade involved with the demolition, utilizing workmen skilled in the trade involved with the repair or replacement of the material in question.

B. All equipment, removed during demolition shall remain on the site, unless otherwise noted. The Owner reserves all rights to claiming material removed during demolition. The contractor is responsible to remove from the site all material not claimed by the Owner. In addition, the contractor is responsible to deliver to the Owner's storage facilities, equipment claimed by the Owner.

END OF SECTION 26 07 00

SECTION 26 24 16 – PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General – provide panelboards in accordance with the Contract Documents.

B. Related Work Specified in Division 26

1. Section 26 05 26 – Grounding and Bonding
2. Section 26 05 53 – Identification for Electrical Systems
3. Section 26 28 14 – Fuses – Low Voltage

C. Related Work Specified in other Divisions of these Specifications.

1. Finish Painting

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and recommendations of the following:

1. Panelboards

   a. U.L. Standards #50 & #67
   b. Federal Standard W-P-115A Type II, Class I and W-C-375B
   c. NEMA Standard PB-1-1971

2. Circuit Breakers

   a. U.L. Standard #489
   b. Federal Standard W-C-375A Amendment No. 4
   c. NEMA Standard AB-1-1969

1.3 SUBMITTALS

A. Refer to Section 26 05 05 concerning the procedures and additional documents for submittals in concert with panelboard submittals. Submittals failing to meet the following criteria will be returned without a review or acceptance.

B. With each panelboard drawing the following is required:

1. Show main devices and lug sizes; branch circuit device sizes and arrangement; bus ampacities; withstandability and short circuit rating; dimensions and construction; gutter

and backbox dimensions; nameplate and legend; protective coating; and all pertinent details of panel, enclosure, cover, and method of securing cover and lock.

1.4 QUALITY ASSURANCE

A. Each panelboard as a complete and finished product shall receive a single integrated equipment rating by the manufacturer. The integrated equipment short circuit wiring shall certify that all equipment is capable of withstanding the thermal and magnetic stress of a fault equal to the value specified on the Drawings. Such rating shall be established by actual tests by the manufacturer on similar equipment. This certification shall be permanently affixed to each panelboard. Test data shall be submitted to the Engineer at time of submission of Acceptance Drawings.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

A. All panelboards are to be Square D or General Electric Co.

2.2 PANELBOARDS IN GENERAL

A. Provide panelboards consisting of an assembly of branch circuits switching and protective devices (circuit breakers) mounted inside a dead front enclosure. Provide the number and size of these branch circuit devices as indicated by the circuiting, on the drawings, and in the schedules. Locations of circuit breakers shall be as indicated in the schedules.

B. Provide the following modifications and additional equipment as shown on the Drawings:

1. Main circuit breakers, as indicated
2. Shunt trip circuit breakers, where indicated
3. Feed through lugs and/or bus, where indicated
4. Ground fault interrupting circuit breakers, where indicated
5. Oversized gutters
6. Door in door construction for power panels wider than 20” or higher than 63”

C. Interiors

1. Rigid removable assembly of copper bus bars and interchangeable bolted branch circuit devices.
2. Bus bars drilled to permit branch circuit devices of all sizes and number of poles to be interchangeable and installed in any spare space of sufficient size, without disturbing adjacent units; without removing main bus or branch circuit connectors and without machining, drilling, or tapping in the field.
3. Arrange bus in sequence or distributed phasing so that multipole circuit breaker can replace any group of single circuit breakers of the same size.

D. Enclosure

1. Code gauge steel box galvanized.
2. Provide a bolt-on ground connector to inside of enclosure.
3. Flush mounted in finished areas and where indicated. Surface mount elsewhere.

E. Front

1. Doors must be provided on all lighting and power panels.
2. Heavy code gauge steel as required to maintain panel face flat.
3. Hold front closed with trim clamps.
4. Factory finished in medium gray enamel or two coats of air-drying lacquer over a rust inhibitor.
5. Provide directory for total number of poles.
6. Provide approved lock. All panels keyed alike. Furnish four (4) sets matching keys to the Owner.
7. Welded angle rest at the bottom of the door to facilitate cover installation.
8. Door over 48" in height shall have auxiliary fasteners at top and bottom of door in addition to lock and catch.

F. Multiple Section Panelboards

1. Each section of multiple section panelboards shall be the same height.
2. Multiple sections shall each contain the same number of poles (e.g. 72 poles equal 2-36 pole panels).

G. Terminal Lugs

1. Bolted type, labeled for either copper or aluminum conductors.
2. Locate main lugs properly at top or bottom, depending where main feeder enters.

H. Electrical Ratings

1. Panelboards are to be rated 208/120 or 480/277 volts, three phase, four (4) wire, full neutral with ampacities as indicated on the Drawings (unless otherwise noted).
2. Short circuit withstand ratings shall be as indicated on the Drawings.
3. Where indicated, provide panelboards having a “service entrance” Type UL label with neutrals factory bonded to frame or enclosure.

I. Circuit Breaker Devices

1. Plastic molded case bolt-on type. Plug-on or plug-in type breakers are unacceptable. Completely sealed enclosure. Toggle type operating handle. Trip ampere rating and ON/OFF indication clearly visible.
2. Thermal-magnetic trip-free, trip-indicating, quick-make, quick-break, with inverse time delay characteristics. Single handle and common tripping multipole breakers.
3. Silver alloy contacts with auxiliary arc-quenching devices.
4. Panelboard must be of the type which will accept the field installation of shunt trip devices of 60 amperes or less on the branch devices.

5. Interrupting capacities shall be "fully rated" with AIC ratings as indicated on the Drawings. As a minimum, 120/208 volt devices shall be not less than 10,000 AIC and 480/277 volt devices shall be not less than 14000A.1.6.
6. Bolted type terminals U.L. listed for either aluminum or copper 75 degrees C cables.
7. Locate next to each breaker or space unit the number/s indicated on the schedules.
8. Shunt trip breakers shall be supplied with 120 volt coils. Provide 120 volt circuit from nearest 120 volt panel to coil. Where shunt trip breakers are in emergency panels provide emergency 120 volt source for same from nearest 120 volt emergency panel.
9. Provide locking device for designated breakers.
10. For HVAC equipment, provide UL listed: HACR type devices.

J. Ground Fault Interrupters

1. Ground fault interrupter branch circuit breakers shall be as indicated on the Drawings. Circuit breakers shall be circuit interrupting which will operate manually for normal switching functions and automatically under overload, short circuit, and 0.005 amp line-to-ground fault conditions. The operating mechanism shall be entirely trip-free so that contact cannot be held close against an abnormal overcurrent, short circuit, or ground fault condition. The device shall be bolt-on type with case construction and shall be interchangeable with standard 1P breakers utilized in the panelboard.
2. All snow melting equipment or pipe heat trace shall be served from GFI breakers.

K. Future Devices

1. Any space within breaker mounting area where a breaker may be mounted, shall be bussed and fully equipped to accept a breaker without any further modifications to the panelboard.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount all panels at a maximum height of 6 feet 6 inches to top unless otherwise noted.

B. Mount surface type panels a minimum one (1) inch off wall on channels.

C. Connect feed through panels to main feeder by insulated parallel gutter taps (O.Z. Electrical Manufacturing Co. – Type PMX or PMX-C). Full size tap for two panels on a common feeder, half the main cable capacity for three or more panels per feeder.

D. Where flushed mounted, the fire integrity of the wall in which it is installed must be maintained.

E. Neatly arrange branch circuit wires and tie together in each gutter with Thomas & Betts nylon "Ty-Raps", or approved equal at minimum (4) four inch intervals.

F. Plug all knockouts removed and not utilized.

G. Provide nameplate and fill out panel directory per Section 26 05 53.

H. Provide grounding and bonding jumpers per Section 26 05 26 and as indicated on the Drawings.

I. Where panelboards are indicated to be replaced, provide backbox enclosure complete with all bussing and breakers. Do not use existing backbox. If new panel cannot be located in the same space as the existing panel, utilize the existing backbox for splicing existing branch circuits to extend to new panel.

J. Where panelboards are flush mounted, provide three (3) - 1” empty conduits stubbed to 12” above accessible ceiling.

3.2 TOUCH UP AND CLEANING

A. Vacuum all backboxes clean of debris after installation and prior to final payment.

B. Touch up scratch marks, etc. with matching paint.

3.3 OBSERVATIONS

A. All panel fronts shall be removed by the Contractor for observation of the panel interiors by the Engineers.

B. Panel fronts shall be removed when directed by the Engineer/Architect for observation (either by floor, or by group of floors on all panels on the project as required by the Engineer/Architect) and reinstalled immediately thereafter the observations.

END OF SECTION 26 24 16

SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. General: Provide wiring devices in accordance with the Contract Documents.

B. Related Work Specified in other Divisions of these Specifications.

1. Finish painting.

C. Color: The numbers shown are for white devices and stainless steel cover plates.

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. Switches

    a. Federal Specifications Standard WS-896E.

2. Receptacles

    a. N.E.M.A. Standard WD-1, 3.2 through 3.10.
    b. U.L. Standard 498 Federal Specification WC596-D.
    c. ANSI.

1.3 SUBMITTALS

A. Submit manufacturer's catalog cuts and specifications for all wiring devices and plates.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The following manufacturers, shortened versions (shown in parentheses), are approved for submission of their products. Other manufacturers may be used, only with approval by the Owner (other). Hubbell catalog numbers have been shown as basis of design.

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).

3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).
5. Arrow-Hart (AH)
6. General Electric (GE)
7. Or approved equal

2.2 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Hubbell; HBL5361W (single), HBL5362W (duplex).

B. Hospital-Grade, Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498 Supplement SD.

1. Hubbell; HBL8310W (single), HBL8300W (duplex).

C. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Hubbell; HBL8300SGWA.
2. Description: Labeled to comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

D. Convenience Receptacle with two (2) USB ports.

1. Hubbell: USB 202X 2 W

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, non-feed through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Hubbell; GF5362WA

2.4 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.

2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.5 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:

1. Hubbell; HBL1221W (single pole), HBL1222W (two pole), HBL1223W (three way), HBL1224W (four way).

C. Pilot Light Switches, 20 A:

1. Hubbell; HBL1221PLC for 120 V and 277 V.
2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

D. Dimmer switches shall be of the type identified in the symbol’s legend.

2.6 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 302 stainless steel with satin finish.
3. Material for Unfinished Spaces: Smooth, high-impact thermoplastic.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof In-Use Cover Plates: NEMA 250, complying with type 3R weather-resistant, thermoplastic with lockable cover.

2.7 MULTIOUTLET ASSEMBLIES

A. Manufacturers:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Wiremold Company (The).
3. Or approved equal

B. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: Metal, with manufacturer's standard “ivory” finish.

D. Wire: No. 12 AWG.

2.8 FINISHES

A. Color: Wiring device catalog numbers in Section Text a reference to the rating or style of device required. Final color selection shall be by the Owner or Architect.

1. Wiring Devices Connected to Normal Power System: White, unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise required by ADA and as shown on the drawings.

B. Coordination with Other Trades:

1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 16 Section "Electrical Identification."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with white-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.

2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION 26 27 26

SECTION 26 28 14 - FUSES-LOW VOLTAGE

PART 1 - GENERAL

1.1 SUMMARY

A. General

1. Provide fuses in accordance with the Contract Documents.

B. Related Work in Specification Division 26

1. Section 26 28 23 – Disconnect Switches – Fused and Non-Fused

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. UL Standard #198
2. UL Standard #977

1.3 SUBMITTALS

A. Provide a complete set of shop drawings to include let-through curves for each type of fuse.

B. Submit listing of all types, sizes and quantity of fuses which will be installed including the location of each.

C. Submit listing of all spare fuses by types, sizes and quantities, which will be furnished for placement in the respective fuse cabinets.

D. Submit dimensioned drawings of each fuse cabinet by type and size.

E. Short circuit current analysis is based upon Bussman fuse characteristics for let-through currents. If Reliance, Cefco or Gould-Shawmut fuses are to be utilized, it is the Electrical Contractor's responsibility to provide the appropriate fuse curves and let-through values which correspond to the Bussman values shown on the Drawings. Submit comparative chart of fuse substitutions for Architect/Engineer and for respective Building Department review prior to acceptance of same substitutions. Comparative chart shall include the following:

1. Cross reference of fuses to be used in place of Bussman fuse type designation indicated on the drawings or specified herein.

F. Submit proof of coordination with the power company for any fuses associated with electric service.

G. Fuses shall comply with the recommendations of the Fault Current and Coordination Study.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

A. Fuses

1. Bussman
2. Cefco
3. Gould-Shawmut
4. Reliance
5. Or approved equal

B. Spare Fuse Cabinet

1. By fuse supplier.

2.2 MATERIALS

A. Branch Circuits

1. General

   a. All fuses shall be labeled as UL Class L or UL Class R, current limiting and rated for up to 200,000 amperes. Time delay Class R fuses shall be so labeled.

2. Branch Circuits (where indicated on the drawings)

   a. Unless noted otherwise on the drawings, all fuses up to 600A shall be UL Class RK5 labeled Time-delay.

3. All fuses shall be so selected as to provide a selectively coordinated system.
4. All fuses shall be of the same manufacturer.

B. Spares

1. Upon completion of the building, the contractor shall provide the Owner with spare fuses as indicated below:

   a. 10 percent (minimum of 3) of each type and rating of installed fuses shall be supplied as spare.
   b. Spare fuse cabinets shall be provided to store the above spares.
   c. Spare fuse cabinets shall be provided as a minimum in the following locations.

1) Main electric room.
2) Each major mechanical equipment room.

C. Labels

1. Paste-on labels for building standard fuses of 600A and below to read:

   EXAMPLE:

   "WARNING: INSTALL CLASS RK1 FUSES ONLY."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fuses shall not be installed until equipment is ready to be energized. Verify the proper fuse size before ordering, regardless of sizes shown on drawings.

B. Provide and install fuses of proper type, voltage and ampere ratings for all fusible devices furnished under this section and all other sections of this specification.

C. Labels

1. Paste appropriate label within each switch, motor starter, or panelboard door or at location next to fuse clips, where fuses shall be furnished and installed by this Contractor. Fill-in, in ink blank spaces on labels for non-standard fuses with appropriate fuse data.

END OF SECTION 26 28 14

SECTION 26 28 23 - DISCONNECT SWITCHES - FUSED AND NON-FUSED

PART 1 - GENERAL

1.1 DESCRIPTION

A. Division 23 Contractor shall furnish all disconnects for Division 23 HVAC and Division 22 Plumbing equipment. As indicated on the drawings and in the Mechanical/Electrical responsibility schedule. Division 26 Contractor shall install disconnect, conduit and wire and terminate all power wiring.

B. Division 26 Contractor shall furnish and install disconnect switches, wire and terminate power wiring for other equipment such as overhead doors, etc.

C. Disconnects protecting the primary side of remote dry type transformers shall be fused to protect the transformer for 100,000 amps RMS symmetrical.

D. Related Work Specified in Division 26

1. Section 26 28 14 – Fuses – Low Voltage
2. Section 26 05 26 – Grounding and Bonding
3. Section 26 05 53 – Identification for Electrical Systems

E. Related Work Specified in other Divisions of these Specifications.

1. Setting of motors and other equipment.

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and the latest applicable recommendations of the following:

1. U.L. Standards #98 (File #4776) and #508.
2. Federal Specifications W-S-865C.
3. NEMA Standard KS1-1975.
4. U.L. 20 and Federal Specification Test Standards for Toggle Switches.

1.3 SUBMITTALS

A. Submit manufacturer's data for all disconnect switches.

B. Identify motor or equipment served by each switch; indicate nameplate inscription.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

A. Safety switches.

1. Shall be of the same manufacturer as the panelboard.

B. Toggle type manual control switches. Shall be of the same manufacturer of the panelboards.

2.2 SAFETY SWITCHES

A. Heavy-duty, horsepower rated, single-throw knife switch with quick-make, quick-break mechanism, capable of full load operations. Meet NEMA and U.S. Government specifications for Class A switches.

B. Provide with contact arc-quenching devices, such as magnetic blowouts or snuffing plates. Provide self-aligning switchblades with silver alloy contact areas and designed so that arcing upon making and breaking does not occur on the final contact surfaces. Provide with high-pressure, spring-loaded contact. Mount switch parts on high-grade insulating base.

C. Enclosure – NEMA 1 with hinged door and defeat-able interlock when switch is in "ON" position and can be positively padlocked in "ON" and "OFF" positions. Utilize NEMA 3R (rain-tight) enclosure for exterior installations.

D. Size, fusing and number of poles as shown or as required. Where fused, the devices must be provided with UL listed rejection feature to reject all but Class R fuses. Provide horsepower rated switch to match motor load if no size is shown. Use 3 pole plus solid neutral switches on four wire circuits and 3 pole switches on all other circuits, unless otherwise noted.

E. Lugs must be UL listed for aluminum and/or copper conductors and be front removable.

2.3 TOGGLE TYPE MANUAL CONTROL SWITCHES

A. Provide switches that operate at their full rating with resistance loads, and at 80% of their rated capacity with motor loads.

B. Switches to be heavy duty and have:

1. Arc-resisting bodies.
2. Slow make-and-break mechanisms
3. Silver alloy contact buttons
4. Side or back wiring with up to No. 10 AWG solid conductors

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Each motor over 1/2 HP (except for 120V-1Ø) shall be provided with a horsepower-rated safety-type disconnect switch.

B. Each piece of equipment utilizing multi-phase power shall be supplied with a safety-type disconnect switch.

C. Each piece of equipment utilizing single-phase power but protected at over 30 amperes shall be supplied with a safety-type disconnect switch.

D. Equipment other than that mentioned above may utilize a toggle type manual control switch properly sized and rated for the equipment it disconnects.

E. Factory installed disconnect switches may be used to satisfy the above requirements with the Architect/Engineer's prior approval.

3.2 MOUNTING

A. Provide connections and wiring to and from each disconnect switch. Support conduit feeder from ceiling or floor.

B. Disconnect switches shall be mounted at adjacent wall or from the floor with independent supports. Switches shall not be mounted on fan housings.

C. Mount switch enclosure rigidly and with proper alignment on building structure or steel supports with centerline of operating handle not more than 5' – 6" above finished floor unless otherwise required. Use steel supports fabricated from standard rolled structural steel shapes or framing channel to provide one-inch separation between enclosure and building wall for vertical flow of air.

D. Install fuses as specified in Section 26 28 14.

E. Completed installation shall contain no extraneous openings.

3.3 IDENTIFICATION

A. Provide identification of all disconnect switches in accordance with Section 26 05 53 of these specifications.

END OF SECTION 26 28 23