

SECTION 15000

BASIC MECHANICAL REQUIREMENTS

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 specifies the basic requirements for mechanical installations and includes requirements common to more than one section. It expands and supplements the requirements specified in sections of Division 1.
- B. Related Sections include the following:
 - 1. Section 01320, "Commissioning Requirements" for Mechanical Contractor scope requirements in support of commissioning efforts.
 - 2. Section 01352, "LEED Requirements."
 - 3. Section 15075, "Mechanical Identification" for valve tag schedules.
 - 4. Section 16415, "Motor Controllers" – The motor controllers required for proper operation of the mechanical equipment shall be purchased by the Mechanical Contractor in conformance with this specification and these controllers shall be installed by the Electrical Contractor.
 - 5. Section 16420, "Variable Frequency Drives" – The variable frequency drives required for proper operation of the mechanical equipment shall be purchased by the Mechanical Contractor in conformance with this specification and these drives shall be installed by the Electrical Contractor.

1.3 DEFINITIONS

- A. Complete and Operational System: A Mechanical system that has been installed, tested, cleaned, signed-off by appropriate Authority and made operational. Completion of Owner training to be part of this requirement.
- B. LEED: Leadership in Energy and Environmental Design, (U.S. Green Building Council Certification).
- C. Mechanical Contractor: The project Contractor responsible for the installation of the Mechanical systems and equipment. This designation refers to the Contractor who performs HVAC and/or Plumbing work.

1.4 SUBMITTALS

- A. General: See Division 1 for general submittal and product substitution requirements.
- B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.
 - 1. Coordination Drawings.

1.5 QUALITY ASSURANCE

- A. Commissioning: Project scope will include commissioning of mechanical systems. The Mechanical Contractor shall support this effort in accordance with the requirements of Section 01320, "Commissioning Requirements."
- B. Installer Qualifications: All work shall be performed by qualified journeymen of their respective trades who are employed by a firm that can demonstrate successful experience with work similar in type, quality and extent to the work required by this project.

1.6 BASIS OF DESIGN (B.O.D.)

- A. General: The following information is intended to provide an overview of the intent and operation of the project Mechanical systems. It is not intended that each and every project Mechanical scope item be captured herein. The absence of a specific item or system in the descriptions below does not absolve the Mechanical Contractor(s) from providing the work identified by other Sections and the Drawings.
 - 1. The Mechanical Contractor(s) shall provide a complete and operational systems and installations.
- B. HVAC Systems Description:
 - 1. Natural gas fired condensing boiler will provide hot water to heat the building.
 - 2. Air handling units (2) shall provide tempered air to VAV boxes for general air conditioning/heating and ventilation.
 - 3. Air conditioning by DX from two (2) condensing units located on pads at rear of building.
- C. Plumbing Systems Description:
 - 1. Cold water/sprinkler entrance on southwest end of building. Hot water generated in Janitor Closet from 30 gal electric type heater. Hot water NOT to be recirculated. Sanitary to exit [pumped] on southeast end of building. Natural gas entrance at southwest end of building with distribution to the boiler and fireplaces.

1.7 CODES, STANDARDS AND AUTHORITIES

- A. General: The following listing is intended to identify the major Codes, Standards, and Authorities Having Jurisdiction, (AHJ's) for the project. This information is at least partially provided on the G-000 series Drawings as well. In the event that there is a discrepancy between the information contained herein and that on the G-000 Drawings, the information herein shall govern.

1. In the event that an item is included on the G-000 Drawings and is not listed herein, compliance with the requirements of said item is required.
 2. The exclusion of an applicable Code, Standard, or AHJ in the list below does not absolve the Contractor from meeting the requirements of said Code, Standard or AHJ.
- B. Codes: Work performed on the project must comply with the requirements of the following Codes:
1. BOCA Building Code, 1999 Edition.
 2. NFPA 101, 2000 edition.
- C. Standards: Work performed on the project must comply with the requirements of the following Industry Standards:
1. ASME A17.1 – 2000 Standards for Elevators and Hoistways
 2. NFPA-13 – Sprinkler Systems
 3. ASHRAE – 90.1 – Energy, 62 – Ventilation, and Principles of Smoke Management.
- D. Authorities Having Jurisdiction: Work performed on the project must comply with the requirements of the following AHJ's:
1. Codes Enforcement Officer – City of Portland
 2. State Fire Marshall – State of Maine
 3. State Plumbing Inspector – State of Maine

1.8 DRAWINGS AND SPECIFICATIONS

- A. General: The drawings and specifications are complimentary.
1. What is shown or noted on the drawings, but not mentioned in the specifications, automatically becomes a part of the specifications.
 2. What is noted in the specifications, but not shown on the drawings, automatically becomes a part of the drawings.
 3. Conflicts between the requirements of the drawings and the specifications must be brought to the immediate attention of the Architect/Engineer.
 - a. The more stringent requirement will apply, unless ruled otherwise by the Architect/Engineer.
 - b. When conflicts or discrepancies are noted, no work shall proceed until the Architect/Engineer has resolved discrepancy or the conflict.
- B. Mechanical Drawings and Division 15 Specification Sections: The Mechanical Contractor shall bear the responsibility of determining full extent of work required by Contract Documents. The Mechanical Contractor shall refer to site, architectural, structural, electrical and other Drawings and Specification Sections that indicate types of construction with which work of this Section must be coordinated. The Mechanical Contractor shall review the work with the General Contractor / Construction Manager to establish the extent of work for their trade, and to determine whether there will be any interference with the work of other trades. If the work is later found to include work required to complete and coordinate the work of another trade, or to interfere with the work of another trade then the changes required to complete the work or to eliminate the interference shall be made without additional cost to the Owner.
1. The Drawings schematically indicate the order of connection of the various system components. Each and every nuance and detail is not indicated. Whether specifically shown or not, all items shall be connected in accordance with Code, the details provided,

accepted trade practices, and the intent of the Contract Documents. Coordinate with the other trades.

- C. Exact locations of ceiling mounted items shall be as shown and detailed on the Architectural reflected ceiling plans.
- D. System components (thermostats, sensors, volume dampers, access doors, etc.) are identified throughout the Drawings for proper system operation. If any component is inadvertently omitted from the drawings, provide that component as per a similar location.

1.9 SUBSTITUTIONS

- A. General: See Division 1 for product substitution requirements.
 - 1. No substitute materials or equipment shall be incorporated in the work without the written approval of the Architect/Engineer.
- B. Substitute materials and equipment submitted for approval must fit within the spaces available with neither substantial alteration nor increased pressure drops or friction losses.
- C. Approval of substitute materials or equipment by the Architect/Engineer shall not relieve the contractor from his responsibility to provide a complete and operational mechanical system.
- D. The Architect/Engineer's decision as to the equality or acceptability of proposed substitutions for the materials and equipment specified shall be final.
 - 1. Any additional costs incurred by such substitutions, including additional costs to other trades, or engineering design costs, shall be borne by the Contractor. This includes costs associated with the design and installation of infrastructure and support systems to facilitate a proposed substitution. This cost will be borne by the Mechanical Contractor.

1.10 MECHANICAL SUBMITTALS

- A. General: Refer to Division 1 for submittal definitions, requirements and procedures.
- B. Submittal of shop drawings, certified performance data, and samples will be accepted only when submitted per Division 1. Data submitted from subcontractors and material suppliers directly to the Architect/Engineer will not be processed.
- C. Submittals for each mechanical trade shall be complete, including all items for which submission and approval is required, and each sheet containing performance data shall be clearly highlighted and marked for the appropriate model or type of equipment to be reviewed. Intended use shall be written on each submittal sheet for each different type of equipment or material to be reviewed (i.e. valves for domestic water or heating hot water, etc.). Incomplete or unmarked submittals WILL BE RETURNED to the Contractor without action.
- D. Submittals shall be organized by specification Section and shall be clearly labeled. Submittals for HVAC and Plumbing items covered by a "shared" Mechanical specification Section, (i.e., hangers and supports, insulation) shall be separate and clearly labeled as to the trade intended.

1. Unclear and/or mixed submittals will not be processed.

E. When two or more items of the same material or equipment are required, (i.e., plumbing fixtures, pumps, valves, air handling units, fans, diffusers, registers and grilles.) they shall be products of the same manufacturer insofar as possible.

1. This does not apply to raw or bulk materials such as pipe and fittings, sheet metal, etc.

1.11 RECORD DOCUMENTS

A. General: Refer to Division 1 for requirements.

B. As work progresses, mark Drawings to indicate revisions to piping and ductwork, size and location including locations dampers and other control devices, filters, boxes and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned for column lines; mains and branches of piping systems, with valves and control devices located and numbered; Change Orders; concealed control system devices.

C. Mark specifications to indicate approved substitutions; Change Orders; actual equipment and materials used.

D. At completion of work and prior to final request for payment, the Mechanical Subcontractor(s) shall submit a complete set of reproducible record drawings showing all systems as actually installed. Drawings submitted shall be in the following format:

1. CADD generated.

a. SMRT design Drawing files may be available as a starting point for CADD generated drawings. A release form will need to be signed to facilitate this.

b. CADD generated drawings shall be ultimately delivered in AutoCAD 2000 format on CD.

2. Valve Tags: Record drawings to include valve tag markers that correspond to the valve tag chart provided under the O&M Manual Section.

1.12 OPERATION AND MAINTENANCE, (O&M) MANUALS

A. General: Refer to Division 1 for procedures and requirements for preparation and submittal of O&M Manuals.

B. Systems Descriptions: Provide description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.

C. Operating Procedures: Provide manufacturer's printed data, including start-up, break-in, routine and normal operating instructions; regulation control, stopping, shut down, and emergency instructions; and summer and winter operating instructions.

D. Maintenance Procedures: Provide for routine preventive maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

- E. Servicing Instructions: Provide instructions, lubrication charts and schedules.
- F. Product Data: Provide copies of all approved submittals.
- G. Valve Schedules: Include valve tag charts in the O&M Manuals. Valve tag charts are as per Section 15075, "Mechanical Identification."

1.13 OWNER TRAINING

- A. General: Refer to Division 1 for general requirements.

1.14 WARRANTIES

- A. Refer to Division 1 for project requirements for warranties. Individual warranties are required for each item of power driven or other mechanical equipment having moving parts, and wherever else specified in Division 15.
 - 1. Submit the warranties specified in Division 15 in a vinyl covered, three ring, binder, tabulated and indexed for easy reference.
- B. Provide complete warranty information for each item, to include date of commencement; duration; and the names, addresses, and telephone numbers and procedures for filing claims and obtaining warranty services.
- C. Duration of warranties shall be not less than one year from the date of substantial completion of the facility, unless the Architect/Engineer has granted prior approval in writing. If the manufacturer's warranty expires less than one year from the date of substantial completion, the mechanical subcontractor at no cost shall provide that warranty service and replacement of parts to the Owner.

1.15 DELIVERY, STORAGE AND HANDLING

- A. General: Refer to Division 1 for material procurement requirements.
- B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.
- C. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.
- D. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

1.16 ENERGY EFFICIENCY

- A. All equipment shall have minimum efficiency as described in ASHRAE Standard 90.1-1999, January 1, 1999 requirements. All equipment suppliers must be aware of the requirements and submitted equipment shall meet these minimum requirements.

1.17 REFRIGERANTS AND OTHER HAZARDOUS MATERIALS

- A. The Mechanical Contractor shall be responsible for the capture, removal, and disposal of materials resulting from the Work.
 - 1. Comply with the requirements of applicable Codes, Standards and Authorities.

1.18 DIVISION OF MECHANICAL AND ELECTRICAL RESPONSIBILITY

- A. General: Line voltage switches, fused switches, outlets, power wiring and fuses necessary to connect and operate all electrically powered equipment specified herein will be furnished and installed as a part of the total project. Coordinate work with Division 16. The intent is to have a complete and operational system. The Mechanical Contractor shall be responsible for furnishing and installing the equipment necessary to provide for the complete and operational system.
- B. Motor Starters: Motor starters are furnished by Division 15 per the Division 16 spec, and shall be installed under Division 16.
- C. Variable Frequency Drives: Variable Frequency Drives are furnished by Division 15 per the Division 16 spec, and shall be installed under Division 16.
- D. Power Wiring: Wiring for equipment shall be furnished and installed as specified under Division 16.
- E. Temperature Control Wiring: Wiring and interlocks shall be furnished and installed under Division 15.
- F. Disconnect Switches: Where not specified in Division 15, switches shall be furnished and installed under Division 16.

1.19 TEMPORARY HEATING

- A. Refer to Division 1 requirements regarding temporary facilities during construction.
- B. The Mechanical Contractor shall provide necessary heating equipment, fuel sources, water treatment, and related items as necessary to meet the intent of the requirements.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 START UP AND TESTING

- A. General: Contractor shall provide all fuel for startup and testing of all equipment provided in this section. Refer to Division 1 for responsibility of electrical power.
- B. The Mechanical Contractor is responsible for startup of all equipment provided in Division 15 Sections.
- C. The Mechanical Contractor shall verify that systems are complete and operational before commencing with balancing work.
- D. Prior to balancing, ensure the following conditions:
 - 1. Systems are started and operating in a safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Final filters are clean and in place.
 - 5. Duct systems are clean of debris.
 - 6. Fans and pumps are rotating correctly.
 - 7. Air outlets are installed and connected.
 - 8. Duct system leakage is minimized.
 - 9. Hydronic systems are flushed, filled and vented.
 - 10. Proper strainer baskets are cleaned and in place.
 - 11. Service and balance valves are open.
- E. Power Outage Test: Entire control system and all mechanical equipment shall be run through a simulated site power outage with emergency generator operation and shall regain standard operation sequences when normal power is restored.
- F. Owner Witness of Test: The Owner shall witness final power outage test. The entire control system and all mechanical equipment shall pass power outage test prior to Owner witness.

3.2 FUNCTIONAL TESTING AND COMMISSIONING

- A. General: The entirety of the Mechanical Equipment and Controls System shall be tested for functional performance for specified operation and control sequences.

3.3 FINAL CLEANING

- A. General: Refer to Division 1 for general requirements regarding final cleaning.
- B. Refer to Division 15 Section, "Testing, Adjusting and Balancing" for requirements of cleaning filters, strainers, and other mechanical systems prior to final acceptance.

END OF SECTION

SECTION 15050

BASIC MECHANICAL MATERIALS AND METHODS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Transition fittings.
 - 3. Dielectric fittings.
 - 4. Mechanical sleeve seals.
 - 5. Sleeves.
 - 6. Escutcheons.
 - 7. Grout.
 - 8. Equipment installation requirements common to equipment sections.
 - 9. Painting and finishing.
 - 10. Concrete bases.
 - 11. Supports and anchorages.
 - 12. Access panels and doors.
 - 13. Motors for Mechanical Equipment
- B. Related Sections include the following:
 - 1. Division 3 Section, "Cast-In-Place Concrete."
 - 2. Division 7 Section, "Firestopping."
 - 3. Division 8 Section, "Access Panels."
 - 4. Division 9 Section, "Painting."

1.3 DEFINITIONS

- A. 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, crawlspaces, and tunnels.

- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- F. The following are industry abbreviations for plastic materials:
 - 1. ABS: Acrylonitrile-butadiene-styrene plastic.
 - 2. CPVC: Chlorinated polyvinyl chloride plastic.
 - 3. PE: Polyethylene plastic.
 - 4. PVC: Polyvinyl chloride plastic.
- G. The following are industry abbreviations for rubber materials:
 - 1. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. General: See Division 1 for general submittal and product substitution requirements.
- B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.
 - 1. Product Data: For transition fittings, dielectric fittings, mechanical sleeve seals, escutcheons.
 - 2. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If

minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors and Frames."
- D. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:
 - 1. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed below.
- B. AWWA Transition Couplings:
 - 1. Cascade Waterworks Mfg. Co.
 - 2. Dresser Industries, Inc.; DMD Div.
 - 3. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
 - 4. JCM Industries.
 - 5. Smith-Blair, Inc.
 - 6. Viking Johnson.
- C. Plastic-to-Metal Transition Fittings:
 - 1. Eslon Thermoplastics.
- D. Plastic-to-Metal Transition Adaptors:
 - 1. Thompson Plastics, Inc.

- E. Plastic-to-Metal Transition Unions:
 - 1. NIBCO, Inc.

 - F. Flexible Transition Couplings for Underground Non-pressure Drainage Piping:
 - 1. Cascade Waterworks Mfg. Co.
 - 2. Fernco, Inc.
 - 3. Mission Rubber Company.
 - 4. Plastic Oddities, Inc.

 - G. Dielectric Unions:
 - 1. Capitol Manufacturing Co.
 - 2. Central Plastics Company.
 - 3. Eclipse, Inc.
 - 4. Epco Sales, Inc.
 - 5. Hart Industries, International, Inc.
 - 6. Watts Industries, Inc.; Water Products Div.
 - 7. Zurn Industries, Inc.; Wilkins Div.

 - H. Dielectric Flanges:
 - 1. Capitol Manufacturing Co.
 - 2. Central Plastics Company.
 - 3. Epco Sales, Inc.
 - 4. Watts Industries, Inc.; Water Products Div.

 - I. Dielectric Flange Kits:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
 - 3. Central Plastics Company.
 - 4. Pipeline Seal and Insulator, Inc.

 - J. Dielectric Couplings:
 - 1. Calpico, Inc.
 - 2. Lochinvar Corp.

 - K. Dielectric Nipples:
 - 1. Perfection Corp.
 - 2. Precision Plumbing Products, Inc.
 - 3. Sioux Chief Manufacturing Co., Inc.
 - 4. Victaulic Co. of America.

 - L. Mechanical Sleeve Seals:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
 - 3. Metraflex Co.
 - 4. Pipeline Seal and Insulator, Inc.
 - 5. Thunderline/Link-Seal
- 2.2 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 15 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

- A. Refer to individual Division 15 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 - 2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated, and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAgl, silver alloy for refrigerant piping, unless otherwise indicated.
- G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Solvent Cements for Joining Plastic Piping:
 - 1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.4 TRANSITION FITTINGS

- A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
 - 1. Underground Piping NPS 1-1/2 (DN 40) and Smaller: Manufactured fitting or coupling.
 - 2. Underground Piping NPS 2 (DN 50) and Larger: AWWA C219, metal sleeve-type coupling.
 - 3. Aboveground Pressure Piping: Pipe fitting.

- B. Plastic-to-Metal Transition Fittings: One-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
- C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions, one end with threaded brass insert, and one solvent-cement-joint end.
- D. Plastic-to-Metal Transition Unions: MSS SP-107, four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
- E. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.5 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
- E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 1. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.
- F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
- G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

2.6 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

2. Pressure Plates: Plastic, include two for each sealing element.
3. 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.

2.7 SLEEVES

- A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) 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 water-stop, 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. Under-deck Clamp: Clamping ring with setscrews.

2.8 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. Escutcheon finishes to be as follows:
 1. Finished area, exposed to view: Polished chrome-plated.
 2. Unfinished areas: Rough brass or similar finish.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass.
- C. One-Piece, Cast-Brass Type: With setscrew.
- D. Split Casting, Cast-Brass Type: With concealed hinge and setscrew.
- E. One-Piece, Stamped-Steel Type: With setscrew or spring clips.
- F. Split-Plate, Stamped-Steel Type: With concealed hinge, setscrew or spring clips.
- G. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- H. Split Casting, Floor-Plate Type: Cast brass with concealed hinge and setscrew.

2.9 GROUT

- A. Description: ASTM C 1107, Grade B, non-shrink and non-metallic, dry hydraulic-cement grout.
 1. Characteristics: Post-hardening, volume adjusting, non-staining, non-corrosive, nongaseous, and recommended for interior and exterior applications.

2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.10 ACCESS PANELS AND DOORS

- A. Panels and doors are to be furnished to provide access to items required in Division 15 Sections and the Mechanical Drawings. Panels and doors are to be furnished per the requirements of Division 8 Section, "Access Doors."

2.11 MOTORS FOR MECHANICAL EQUIPMENT

A. Motor Characteristics:

1. Motors - 3/4 HP and Larger: Three phase.
2. Motors - Smaller Than 3/4 HP: Single phase.
3. Frequency Rating: 60 Hz.
4. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.
5. Service Factor: 1.15 for open drip-proof motors; 1.0 for totally enclosed motors.
6. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
7. 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.
8. Enclosure: Open drip-proof.

B. Poly-phase Motors:

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Premium efficiency.
3. Stator: Copper windings, unless otherwise indicated.
 - a. Multi-speed motors shall have separate winding for each speed.
4. Rotor: Squirrel cage, unless otherwise indicated.
5. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.
6. Temperature Rise: Match insulation rating, unless otherwise indicated.
7. Insulation: Class F, unless otherwise indicated.
8. Code Letter Designation:
 - a. Motors: 15 HP and Larger: NEMA starting Code F or G.
 - b. Motors Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.
 - c. Finish: Gray enamel.

C. Poly-phase Motors with Additional Requirements:

1. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - a. Designed with critical vibration frequencies outside operating range of controller output.
 - b. Temperature Rise: Matched to rating for Class B insulation.
 - c. Insulation: Class H.
 - d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

D. Single-Phase Motors:

1. Type: One of the following, to suit starting torque and requirements of specific motor application:
 - a. Permanent-split capacitor.
 - b. Split-phase start, capacitor run.
 - c. Capacitor start, capacitor run.
2. Shaded-Pole Motors: For motors 1/20 hp and smaller only.
3. 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.
4. 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.
5. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:
 - a. Measure winding resistance.
 - b. Read no-load current and speed at rated voltage and frequency.
 - c. Measure locked rotor current at rated frequency.
 - d. Perform high-potential test.

2.12 PIPE EXPANSION FITTINGS AND LOOPS

- A. Application: When the length of a piping run and the temperature range that the piping will experience will require expansion compensation refer to the ASHRAE 2000 Handbook – HVAC Systems and Equipment and ASME B31.9 for the proper application of expansion compensation.

PART 3 - EXECUTION

3.1 ROUGH-IN

- A. General: Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment and fixtures to be connected. Refer to equipment and fixture specifications in Divisions 2 through 16, and to approved shop drawings, for rough-in requirements.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. General: Coordinate equipment and materials for installation with other building components.
- B. Verify dimensions by field measurements.
- C. Arrange for chases, slots, and openings in other building components to allow for mechanical installations.
- D. Coordinate the installation of required supporting devices.
 - 1. Support suspended equipment from walls or from structural frames. Do not support equipment from metal roof deck.
- E. Sequence, coordinate and integrate installations of mechanical materials and equipment for efficient flow of the work.
- F. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials. Refer to Division 1.
- G. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
- H. Install access panels to allow access to equipment and other system components that require servicing or adjustment per the requirements of Division 8.
- I. Coordinate the installation of mechanical materials and equipment above ceilings with suspension system, lighting fixtures, and other installations.

3.3 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.

- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following. Use One-piece escutcheons wherever possible in new construction. Split-casting units acceptable for installation on existing piping systems.
 - 1. Piping with Fitting or Sleeve Protruding from Wall: Deep-pattern type.
 - 2. Chrome-Plated Piping: Cast-brass type with polished chrome-plated finish.
 - 3. Insulated Piping: Stamped-steel type with spring clips.
 - 4. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Cast-brass type with polished chrome-plated finish.
 - 5. Bare Piping at Ceiling Penetrations in Finished Spaces: Cast-brass type with polished chrome-plated finish.
 - 6. Bare Piping in Unfinished Service Spaces and Equipment Rooms: Cast-brass type with rough-brass finish.
 - 7. Bare Piping at Floor Penetrations in Equipment Rooms: Floor-plate type.
- M. Sleeves are not required for core-drilled holes.
- N. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, 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 equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend 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 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. Steel Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
 - c. 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 (50 mm) above finished floor level. Refer to Division 7 Section "Sheet Metal Flashing and Trim" for flashing.
 - 1) Seal space outside of sleeve fittings with grout.
 - 4. 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 Division 7 Section "Joint Sealants" for materials and installation.

- O. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
 - 2. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) 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.

- P. 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 (25-mm) 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.

- Q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 Section "Through-Penetration Firestop Systems" for materials.

3.4 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 - 3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 5. PVC Nonpressure Piping: Join according to ASTM D 2855.
 - 6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.5 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - 3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
 - 4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.6 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

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

3.7 CLEAN CONSTRUCTION MEASURES

- A. General: Take care during construction to maintain the integrity and cleanliness of duct, pipe and equipment systems.
- B. Ductwork must be capped during construction, dust and debris in ductwork is not acceptable. Interior of ductwork and air systems must be completely cleaned.
- C. Exposed ends of piping systems and equipment/fixture connection ports shall be capped, plugged, or otherwise covered during construction.

3.8 PAINTING

- A. Painting of mechanical systems, equipment, and components is specified in Division 9 Section "Painting."
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.9 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - 7. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section "Cast-in-Place Concrete."

3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 5 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

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

3.11 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor mechanical materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.12 GROUTING

- A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION

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SECTION 15060

HANGERS AND SUPPORTS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by this Section.

1.2 SUMMARY

- A. This Section includes hangers and supports for mechanical system piping and equipment.
- B. Related Sections include the following:
 - 1. Division 5 Section "Metal Fabrications" for materials for attaching hangers and supports to building structure.
 - 2. Division 13 Sections on fire-suppression piping for fire-suppression pipe hangers.
 - 3. Division 15 Section "Mechanical Vibration Controls and Seismic Restraints" for vibration isolation and seismic restraint devices.

1.3 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."

1.4 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.

- D. Design and obtain approval from authorities having jurisdiction for seismic restraint hangers and supports for piping and equipment.

1.5 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.

1.6 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. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Pipe Hangers:
 - a. All Plastics and Fiberglass, Inc.
 - b. B-Line Systems, Inc.
 - c. Carpenter & Patterson, Inc.
 - d. Century Composites, Inc.
 - e. Globe Pipe Hanger Products, Inc.
 - f. Grinnell Corp.
 - g. GS Metals Corp.
 - h. Michigan Hanger Co., Inc.
 - i. National Pipe Hanger Corp.

- j. PHD Manufacturing, Inc.
 - k. PHS Industries, Inc.
 - l. Piping Technology & Products, Inc.
2. Channel Support Systems:
- a. B-Line Systems, Inc.
 - b. Grinnell Corp.; Power-Strut Unit.
 - c. GS Metals Corp.
 - d. Michigan Hanger Co., Inc.; O-Strut Div.
 - e. National Pipe Hanger Corp.
 - f. Thomas & Betts Corp.
 - g. Unistrut Corp.
 - h. Wesanco, Inc.
3. Thermal-Hanger Shield Inserts:
- a. Carpenter & Patterson, Inc.
 - b. Michigan Hanger Co., Inc.
 - c. PHS Industries, Inc.
 - d. Pipe Shields, Inc.
 - e. Rilco Manufacturing Co., Inc.
 - f. Value Engineered Products, Inc.
4. Powder-Actuated Fastener Systems:
- a. Gunnebo Fastening Corp.
 - b. Hilti, Inc.
 - c. ITW Ramset/Red Head.
 - d. Masterset Fastening Systems, Inc.
- 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. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with 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 (690-kPa) minimum compressive-strength insulation, encased in sheet metal shield.
 - 1. Material for Cold Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.
 - 2. Material for Hot Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate.
 - 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 (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

- A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pullout and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Anchor Fasteners: Insert-type attachments with pullout 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 (34.5-MPa), 28-day compressive strength.

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 (DN15 to DN750).
 - 2. Hanger loop of continuous filament fiberglass and Dow Derakane vinyl ester resin to be used on all piping suspended below the first floor slab. Metal rod, lock nuts, support and safety bar to be fabricated from T-316 stainless steel.

3. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F (49 to 232 deg C) pipes, NPS 4 to NPS 16 (DN100 to DN400), requiring up to 4 inches (100 mm) of insulation.
4. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN20 to DN600), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
5. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24 (DN15 to DN600), if little or no insulation is required.
6. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4 (DN15 to DN100), to allow off-center closure for hanger installation before pipe erection.
7. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8 (DN20 to DN200).
8. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN15 to DN200).
9. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN15 to DN200).
10. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2 (DN15 to DN50).
11. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8 (DN10 to DN200).
12. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3 (DN10 to DN80).
13. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30 (DN15 to DN750).
14. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
15. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 (DN100 to DN900), with steel pipe base stanchion support and cast-iron floor flange.
16. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN100 to DN900), with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
17. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36 (DN65 to DN900), if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
18. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN25 to DN750), from two rods if longitudinal movement caused by expansion and contraction might occur.
19. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20 (DN65 to DN500), from single rod if horizontal movement caused by expansion and contraction might occur.
20. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN50 to DN1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
21. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24 (DN50 to DN600), if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
22. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN50 to DN750), 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 (DN20 to DN500).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN20 to DN500), 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 (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) 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 (49 to 232 deg C) 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 (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (675 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1350 kg).

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

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 (690-kPa) 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 (32 mm).
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. For piping installed below the first floor slab the maximum spacing between hangers shall be 4'-0" with a minimum of two hangers per ten-foot section of pipe.
- 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. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.

- c. Do not exceed pipe stress limits 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. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN100) 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. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN100) 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 (DN8 to DN90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN125 and DN150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN200 to DN350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN400 to DN600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
5. Pipes NPS 8 (DN200) and Larger: Include wood inserts.
6. Inset Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.4 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.

3.5 ADJUSTING

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

3.6 PAINTING

- A. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 Section "Painting."
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 15071

MECHANICAL VIBRATION AND SEISMIC CONTROLS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by the Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Vibration Isolators.
 - 2. Duct and Pipe Isolators.
 - 3. Vibration Isolation Equipment Bases.
 - 4. Seismic Restraint Devices.
- B. Related Sections include the following:
 - 1. Section 15050, "Basic Mechanical Materials and Methods" for thermal expansion compensation in piping systems.
 - 2. Section 15060, "Hangers and Supports" for piping, duct, and equipment hangers and supports as well as requirements for strut components.

1.3 DEFINITIONS

- A. A_v : Effective peak velocity related acceleration coefficient.
- B. OSHPD: Office of Statewide Health Planning & Development for the State of California. OSHPD assigns a unique anchorage preapproval "R" number to each seismic restraint it tests. The number describes a specific device applied as tested.
- C. Withstand: 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."

1.4 SEISMIC REQUIREMENTS

- 1. General: Performance requirements to be used in the design of seismic controls are as identified on drawing G1001.

1.5 SUBMITTALS

- A. General: See Division 1 for general submittal and product substitution requirements.
- B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.
 - 1. Product Data: Include load deflection curves for each vibration isolation device.
 - 2. Shop Drawings: Signed and sealed by a qualified professional engineer where required by applicable Code. Include the following:
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
 - c. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
 - d. Seismic-Restraint Details: Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
 - e. Submittals for Interlocking Snubbers: Include load deflection curves up to 1/2-inch (13-mm) deflection in x, y, and z planes.
 - 3. Welding certificates.
 - 4. Manufacturer Seismic Qualification Certification: Submit certification that all specified equipment will withstand seismic forces identified in "Performance Requirements" Article above. Include the following:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.6 QUALITY ASSURANCE

- A. Seismic-restraint devices shall have horizontal and vertical load testing and analysis performed according to OSHPD and shall bear anchorage pre-approval "R" number, from OSHPD or another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If pre-approved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer. Testing and calculations must include both shear and tensile loads and 1 test or analysis at 45 degrees to the weakest mode.
- B. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate installation of equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed below.
- B. Vibration Isolators:
 - 1. Ace Mounting Co., Inc.
 - 2. Amber/Booth Company, Inc.
 - 3. B-Line Systems, Inc.
 - 4. Isolation Technology, Inc.
 - 5. Kinetics Noise Control, Inc.
 - 6. Mason Industries, Inc.
 - 7. Vibration Mountings & Controls/Korfund.
- C. Duct and Pipe Vibration Isolators
 - 1. Mason Industries, Inc.
 - 2. Mason-Mercer, (Mason Industries, Inc. – Mercer Rubber Co.)
 - 3. The Metraflex Co.
 - 4. Amber/Booth Company, Inc.
- D. Vibration Isolation Roof Curb Rails:
 - 1. Amber/Booth Company, Inc.
 - 2. Isolation Technology, Inc.
 - 3. Kinetics Noise Control, Inc.
 - 4. Mason Industries, Inc.
 - 5. Vibration Mountings & Controls/Korfund.
- E. Vibration Isolation Equipment Bases:
 - 1. Amber/Booth Company, Inc.
 - 2. Isolation Technology, Inc.
 - 3. Kinetics Noise Control, Inc.
 - 4. Mason Industries, Inc.
 - 5. Vibration Mountings & Controls/Korfund.
- F. Seismic Restraint Devices:
 - 1. Amber/Booth Company, Inc.
 - 2. B-Line Systems, Inc.
 - 3. Kinetics Noise Control, Inc.

4. Loos & Co., Inc.; Cableware Technology Division.
5. Mason Industries, Inc.
6. TOLCO Incorporated.
7. Unistrut Diversified Products Co.; Wayne Manufacturing Division.
8. Vibration Mountings & Controls/Korfund.

2.2 VIBRATION ISOLATORS

- A. General: The following applies to items specified in the paragraphs below.
 1. Minimum static deflections are identified in the schedule at the end of Part 3.
 2. Vibration Isolators that have a seismic function as well (those which incorporate limit stops and/or snubbers) shall not be constructed of aluminum or cast iron materials.
- B. Elastomeric Grommet, (Bushing): Oil- and water-resistant elastomer, bolt-isolating bushing.
 1. Material: Bridge Bearing Neoprene.
 2. Basis of Design: Mason Industries, Inc. Type **HG**.
- C. Elastomeric Isolator Pads: Oil- and water-resistant elastomer, arranged in single or multiple layers, molded with a non-slip pattern, factory cut to sizes that match requirements of supported equipment.
 1. Material: Standard neoprene.
 2. Shims, (between multiple layers): 16 ga. Steel.
 3. Basis of Design: Mason Industries, Inc. Types **W**, **SW** & layered combinations thereof.
- D. Elastomeric Isolator Pads & Plates: Oil- and water-resistant elastomer, arranged in single or multiple layers, molded with a non-slip pattern and galvanized steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
 1. Material: Standard neoprene or bridge-bearing neoprene, complying with AASHTO M 251.
 2. Shims, (between multiple layers): 16 ga. Steel.
 3. Basis of Design: Mason Industries, Inc. Type **SWM** & layered combinations thereof.
- E. Elastomeric Mounts (Mason Spec. A): Double-deflection type, with molded, oil-resistant neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
 1. Vibration Isolating Material: Neoprene.
 2. Basis of Design: Mason Industries, Inc. Type **ND**.
- F. Restrained Elastomeric Mounts: All-directional elastomeric mountings with seismic restraint.
 1. Materials: Cast-ductile-iron housing containing two separate and opposing, molded, bridge-bearing neoprene elements that prevent central threaded sleeve and attachment bolt from contacting the casting during normal operation.
 2. Shock-absorbing materials: Neoprene.
 3. Basis of Design: Mason Industries, Inc. Type **BR**.

- G. Spring Isolators (Mason Spec. B): Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside. Baseplates shall limit floor load to 100 psig (690 kPa).
 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
 7. Basis of Design: Mason Industries, Inc. Type **SFLH**.
- H. Restrained Spring Isolators (Mason Spec. D): Freestanding, steel, open-spring isolators with seismic restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Basis of Design: Mason Industries, Inc. Type **SLR**.
- I. Housed Spring Isolators: Housed spring isolator with integral seismic snubbers.
1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
 2. Base: Factory drilled for bolting to structure.
 3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch (6-mm) travel before contacting a resilient collar.
 4. Basis of Design: Mason Industries, Inc. Type **SSLFH**.
- J. Elastomeric Hangers: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.
1. Basis of Design: Mason Industries, Inc. Type **HD & WHD**.
- K. Spring Hangers (Mason Spec. F): Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 7. Basis of Design: Mason Industries, Inc. Type 30N.
- L. Spring Hangers with Vertical-Limit Stop (Mason Specs. G & H): Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Elastomeric Element: Molded, oil-resistant neoprene.
 7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 8. Basis of Design: Mason Industries, Inc. Type PC30N.

2.3 DUCT AND PIPE ISOLATORS

- A. General: Hanger isolators listed in above are applicable to duct and piping applications as well as suspended equipment. Additionally, items identified below are specific to duct and piping installations.
- B. Thrust Limits (Mason Spec. I): Combination coil spring and elastomeric insert with spring and insert in tension, and with a load stop. Include rod and angle-iron brackets for attaching to equipment.
1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Elastomeric Element: Molded, oil-resistant neoprene.
 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.
 8. Basis of Design: Mason Industries, Inc. Types WBD.

- C. Acoustical Wall, Ceiling or Floor Seal (Mason Spec Q): Split steel sleeve held in place by stainless steel band clamps. Isolating material between sleeve and service pipe to be closed cell neoprene sponge.
 - 1. Basis of Design: Mason Industries, Inc. Type **SWS**.
 - 2. Acceptable Option: Field fabricated seals consisting of sheet metal sleeve, stainless steel band clamps, and mineral wool or fiberglass isolating packing.
 - a. Seal ends of wool with silicone sealant.

- D. Molded Rubber Pipe Expansion Joint (Mason Spec. O): Double sphere shaped with steel flanged end connections; peroxide or sulfur cured EPDM cover, reinforced with multiple layers of Kevlar or nylon cord; molded reinforcing ring. Unit to be designed to allow for tensile, compressive, angular and transverse movement. Units to be rated for minimum continuing operating pressures of 250psig at 170°F and 215 psig at 250°F.
 - 1. Control Rods: Rods or cables and associated hardware as recommended by unit manufacturer.
 - 2. Basis of Design: Mason Industries, Inc. – Mercer Rubber Co. Type **SFDEJ**.

- E. Stainless Steel Hose (Mason Spec. P): Type 321 corrugated stainless steel hose with overbraid; Male NPT ends for 2-inch and smaller, 150# flanged for 2-1/2-inch and larger.
 - 1. Basis of Design: Mercer Rubber Co. Type **BSS-GU-MN & BSS-GU-RF-150**.
 - 2. Acceptable Option: Bronze corrugated hose with overbraid; for use with copper piping systems; soldered ends.
 - a. Basis of Design: Mercer Rubber Co. Type **BBF**.

- F. Molded Rubber Duct Expansion Joint: Flexible duct connectors constructed of natural rubber or synthetic liner, nylon or steel reinforced as necessary to meet operating pressures and/or vacuum conditions; 304 stainless steel bands or flanged end connections.
 - 1. Basis of Design: Mercer Rubber Co. **Duct Type Expansion Joints**.
 - 2. Acceptable Option: Expansion Joints fabricated by the ductwork supplier as acceptable pending performance standards are equal to Basis of Design.

2.4 VIBRATION ISOLATION EQUIPMENT BASES

- A. Steel Base (Mason Specs. J & K): Factory-fabricated, welded, structural steel bases and rails.
 - 1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps.
 - 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
 - 3. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 - 4. Basis of Design: Mason Industries, Inc. Types **WF**, (base) & **ICS**, (rails). Mounts and snubbers as scheduled at the end of this Section.

- B. Inertia Base (Mason Spec. L): Factory-fabricated, welded, structural steel bases ready for field-applied, cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps.
 - a. Bolted modular type assembly.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.
5. Basis of Design: Mason Industries, Inc. Type **BMK**. Mounts and snubbers as scheduled at the end of this Section.

2.5 SEISMIC-RESTRAINT DEVICES

- A. General: Certain items identified in paragraphs above have seismic control capabilities in addition to vibration isolation, (duct thrust restraints, restrained mounts and springs, etc.). The items identified in the following paragraphs are components specific to seismic control.
 1. Base Mounted Equipment: Items identified above and herein comprise restraint systems for base mounted equipment.
 2. Suspended Equipment, Piping and Ductwork Restraint Systems: Restraint systems for these items shall consist of tension and compression, (strut) components, or tension only, (cable) components. In either case, provide necessary ancillary appurtenances as required to meet seismic restrain design criteria. Each and every component is not identified herein.
 - a. A single manufacturer shall provide systems and their components.
 - b. Components shall be intended and listed for use with each other, (do not mix and match components not intended for use with each other).
 - c. Systems may include:
 - 1) Attachments to structure.
 - 2) Braces and other means of augmenting standard hanger and support assemblies.
 - 3) Threaded rod stiffeners.
 - d. Restraint devices constructed of aluminum or cast iron materials are not acceptable.
- B. Strut Restraint Systems: Strut components, (channel support systems) are as identified in Section 15060, "Hangers and Supports."
 1. Basis of Design: As manufactured by B-Line Systems, Inc.
- C. Restraining Cable Systems: Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable engagement.
 1. Basis of Design: As manufactured by Mason Industries, Inc.
- D. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251, with a flat washer face.
 1. Basis of Design: Mason Industries, Inc. Types PB & HG.

- E. Seismic Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 - 1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
 - 2. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251.
 - 3. Basis of Design: Mason Industries, Inc. Types Z-1225 & Z-1011.
- F. Anchor Bolts: Seismic-rated, drill-in, and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488/E 488M.
 - 1. Basis of Design: Mason Industries, Inc. Types SAS & SAB.

2.6 FACTORY FINISHES

- A. Manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 1. Powder coating on springs and housings.
 - 2. All hardware shall be electro-galvanized. Hot-dip galvanize metal components for exterior use.
 - 3. Baked enamel for metal components on isolators for interior use.
 - 4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EQUIPMENT VIBRATION ISOLATOR APPLICATION

- A. General: Provide vibration isolation in accordance with the schedule at the end of this Section.
 - 1. Seismic Controls: Vibration isolators identified in the schedule at the end of this Section may include limit stops that serve seismic functions. Where additional, or independent snubbers and restraints are required, these items are identified in the schedule.
- B. Suspended Equipment:
 - 1. Suspended in-line Hydronic Pumps, (Section 15185): Spring isolators with vertical limit stops, minimum (4) per pump.
 - a. HVAC Equipment Tags: P-1, P-2.

3.2 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements, installation tolerances, and other conditions affecting performance.

- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 EQUIPMENT INSTALLATION, GENERAL

- A. Base mounted equipment / isolation assemblies to be secured to structure. "Free floating" equipment is not acceptable.
 - 1. Install resilient bolt isolation washers on equipment anchor bolts.
- B. Fill concrete inertia bases, after installing base frame, with 3000-psi concrete; trowel to a smooth finish.
 - 1. Cast-in-place concrete materials and placement requirements are specified in Division 3.
- C. Concrete Bases: Anchor equipment to concrete base according to supported equipment manufacturer's written instructions for seismic codes at Project site.
- D. Support Equipment: Install isolators on support equipment that is part of an isolated system. "Isolated systems" are identified by whether or not a major piece of system equipment is isolated in the schedule at the end of this Section.
 - 1. Base Mounted Support Equipment: Types **W**, **SW** & **SWM**, (match major equipment type).
 - 2. Suspended Support Equipment: Types **HD** & **WHD**.

3.4 DUCT AND PIPING SYSTEMS INSTALLATION

- A. General: Piping and ductwork systems shall be supported in accordance with their respective Sections as well as the requirements of Section 15060, "Hangers and Supports." In addition to those requirements, described herein are requirements to address vibration and seismic forces.
- B. Connections to Equipment, General: Piping and Duct connections to isolated pieces of Mechanical equipment shall include the following means of limiting vibration transmissions to the piping and ductwork.
 - 1. Equipment Connections: Install duct and pipe isolators at the inlet and outlet connections to each piece of isolated equipment. Exact locations of isolators as detailed on the Drawings.
 - a. Types **SFDEJ**, **BSS-GU-MN**, **BSS-GU-RF-150**, **BBF** & **Duct Type**.
 - 2. Suspended Piping and Ductwork Either Side: Isolate pipe and duct runs leading to and/or away from each piece of isolated equipment for a distance of 50 feet. Pipe and duct support isolator types to match those used on the isolated equipment. Minimum static deflection to be one-half that of the equipment isolator.
 - a. Ducts and pipes serving equipment isolated by elastomeric pads or mounts;
 - 1) Seismic & Non Seismic Applications: Types **HD** & **WHD**.
 - b. Ducts and pipes serving equipment isolated by springs;
 - 1) Seismic Application: Type **PC30N**.
 - 2) Non-Seismic Application: Type **30N**.

3. Wall, Floor and Hard Ceiling Penetrations: Where services leading to and/or away from isolated equipment penetrate walls, floors and/or hard ceilings within 50 feet of the equipment, the wall and/or floor penetrations shall be acoustically isolated.
 - a. Type **SWS**.
 - 1) Exception: Where walls and/or floors penetrated are fire rated, provide a sleeve and appropriate fire stopping in lieu of this acoustical isolator. Fire Stopping is specified in Division 7.
 4. Riser Isolation: Isolation of vertical riser-through-floor penetrations within 50 feet of isolated equipment shall be accomplished via using pairs of isolators that transmit riser load from a heavy-duty riser clamp, (welded to the pipe) or welded attachments.
 - a. Risers servicing equipment isolated by elastomeric pads or mounts;
 - 1) Types **W** & **SW** with a steel plate between the isolator and riser clamp.
 - b. Risers servicing equipment isolated by springs;
 - 1) Type **SLR**.
 5. Base of Riser and Horizontal Floor Supported Services: Isolation of floor supported piping and ductwork within 50 feet of isolated equipment shall be accomplished via using pairs of isolators which transmit load from a service-supporting cross member. Pipe and duct support isolator types to match those used on the isolated equipment. Minimum static deflection to also match that of the equipment isolator.
 - a. Ducts and pipes serving equipment isolated by elastomeric pads or mounts;
 - 1) Types **HD** & **WHD**.
 - b. Ducts and pipes serving equipment isolated by springs;
 - 1) Type **SLR**.
- C. Duct Connections to Fans: Install a pair of thrust restraints at duct connections the following fans. Thrust restraints shall bridge flexible duct connectors and shall be installed along either side of the centerline of the thrust.
1. All suspended fans.
 - a. Type **WBD**.
 2. Base mounted fans that generate more than 4-inches of static pressure.
 - a. Type **WBD**.
 3. Exception: Thrust restraints are not required where thrust forces do not exceed 10% of the equipment weight.
- D. Common Support Requirements: Where piping is intended to be installed on a common, (trapeze) rack, the following shall apply;
1. Do not install isolated and non-isolated services on the same rack.
 2. Rack isolation shall be of a type and meet the requirements of the most stringent isolation
 3. Services shall be clipped on to the rack, (or attached via guides if the plans specifically call for this). Neoprene isolators shall be installed between the pipe and the rack/clip.
- 3.5 SEISMIC CONTROLS INSTALLATION
- A. General: Install seismic bracing to limit movement of natural gas piping in all directions. Provide stiffeners or otherwise augment standard supports at brace locations to accommodate seismic forces imposed.
1. Threaded hanger rod at brace locations shall be capable of supporting both standard working loads as well as seismic tensile and compressive loads.

- a. Where rod length exceeds allowable unbraced rod length, provide standard 12 gauge strut rod stiffeners and clamp reinforcements over the entire length of the rod.
 - b. The maximum allowable unbraced length of rods shall not exceed 18-inches for 3/8-inch rod and 24-inches for 1/2 through 7/8-inch rod. Installing contractor to verify maximum unbraced rod lengths allowable via calculations.
- B. Equipment Controls, General: Certain seismic control requirements are satisfied by components identified in the vibration isolation schedule at the end of this Section, (limit stops and housings). The installations contained herein are required in addition to those items.
1. Controls must not overload building structural components. Attach controls to major building structural elements such as beams, columns and concrete floors. Avoid attaching to open joints and lighter weight elements.
- C. Piping Controls, General: Install sway bracing on pipe and duct systems.
1. Bracing to consist of tension only cable systems where piping includes vibration isolated hangers.
 - a. Install cable with 1/2-inch of slack to accommodate isolator motion.
 - b. Provide stiffeners on hanger rods if calculations dictate.
 2. Where piping does not include vibration-isolated hangers and supports, tension only cable or tension-and-compression strut systems may be used.
 - a. Install cable systems taut.
 - b. Provide stiffeners on hanger rods if calculations dictate.
 3. Cable Systems, General: Install cables so they do not bend across sharp edges of adjacent equipment or building structure.
 4. Strut Systems, General: Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers.
- D. Piping General Brace Location Requirements: Each straight run of piping shall include a minimum of (2) transverse and (1) longitudinal brace.
1. If the overall length of the run exceeds maximum brace spacing identified below, than additional bracing must be installed.
 2. Transverse brace locations shall include the ends of each straight run.
 3. A transverse brace within 2-feet of a 90° bend may meet the spacing requirements of a longitudinal brace in the adjacent 90° section to the order of half the maximum allowable longitudinal spacing minus 2 feet.
 4. Install a transverse brace within 2-feet of each pipe drop or rise to an equipment connection.
 5. Install a transverse brace within 2 times the duct width of each drop or rise to an equipment connection.
- E. Copper and Steel Piping Systems (Welded, Soldered, Brazed, Grooved, or Threaded): Install bracing in accordance with the following maximum spacing:
1. Transverse Brace Spacing: 50 feet.
 2. Longitudinal Braces: Install at intervals of 80 feet, maximum.

3.6 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing:

1. Isolator seismic-restraint clearance.
2. Isolator deflection.
3. Snubber minimum clearances.

3.7 ADJUSTING

- A. Adjust isolators after piping systems have been filled and equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop.
- D. Adjust active height of spring isolators.
- E. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.
- F. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.
- G. Adjust snubbers according to the written recommendations of the manufacturer.

3.8 CLEANING

- A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

END OF SECTION

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SECTION 15075

MECHANICAL IDENTIFICATION

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by this Section.

1.2 SUMMARY

- A. This Section includes the following mechanical identification materials and their installation:
 - 1. Equipment nameplates.
 - 2. Equipment markers.
 - 3. Equipment signs.
 - 4. Access panel and door markers.
 - 5. Pipe markers.
 - 6. Duct markers.
 - 7. Stencils.
 - 8. Valve tags.
 - 9. Valve schedules.
 - 10. Warning tags.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Valve numbering scheme.
- D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 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.

1.5 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 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed below.
- B. Identification Systems:
 - 1. Seaton Name Plate Co.
 - 2. Brady: Signmark Div.; W.H. Brady Co.
 - 3. Kolbi Industries, Inc.

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 (64 by 100 mm) for control devices, dampers, and valves; 4-1/2 by 6 inches (115 by 150 mm) for equipment.
- C. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
- 1. Data: Instructions for operation of equipment and for safety procedures.
 - 2. Engraving: Manufacturer's standard letter style, of sizes and with terms to match equipment identification.
 - 3. Thickness: 1/16 inch (1.6 mm) for units up to 20 sq. in. (130 sq. cm) or 8 inches (200 mm) in length, and 1/8 inch (3.2 mm) for larger units.
 - 4. Fasteners: Self-tapping, stainless steel screws or contact-type, permanent adhesive.
- D. Access Panel and Door Markers: 1/16-inch- (1.6-mm-) thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch (3.2-mm) center hole for attachment.
- 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 (150 mm): Full-band pipe markers extending 360 degrees around pipe at each location.
 - 4. Pipes with OD, including insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe 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.
- D. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

- E. Plastic Tape: Continuously printed, vinyl tape at least 3 mils (0.08 mm) thick with pressure-sensitive, permanent-type, self-adhesive back.
 - 1. Width for Markers on Pipes with OD [Including Insulation] Less Than 6 Inches (150 mm): 3/4-inch (19 mm) minimum.
 - 2. Width for Markers on Pipes with OD [Including Insulation] 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

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.

2.5 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches (32 mm) for ducts; and minimum letter height of 3/4 inch (19 mm) for access panel and door markers, equipment markers, equipment signs, and similar operational instructions.
 - 1. Stencil Material: Metal or fiberboard.
 - 2. Stencil Paint: Exterior, gloss, alkyd enamel black, unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1, unless otherwise indicated.

2.6 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers, with numbering scheme approved by Architect. Provide 5/32-inch (4-mm) hole for fastener.
 - 1. Material: 0.0375-inch- (1-mm-) thick stainless steel.
 - 2. Valve-Tag Fasteners: Brass wire-link or beaded chain; or S-hook.

2.7 VALVE SCHEDULES

- A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
 - 2. Frame: Extruded aluminum.

3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.8 WARNING TAGS

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.
 1. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum.
 2. Fasteners: Brass grommet and wire.
 3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
 4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

- A. Products specified are for applications referenced in other Division 15 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. Fuel-burning boilers.
 2. Pumps, compressors, chillers, condensers, and similar motor-driven units.
 3. Heat exchangers, coils, evaporators, heat recovery units, and similar equipment.
 4. Fans, blowers, primary balancing dampers, and mixing boxes.
 5. Packaged HVAC central-station and zone-type 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 (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), 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 such as gas outlets.
 - b. Fire department hose valves and hose stations.
 - c. Meters, gages, thermometers, and similar units.
 - d. Fuel-burning boilers.
 - e. Pumps, compressors, chillers, condensers, and similar motor-driven units.
 - f. Heat exchangers, coils, evaporators, heat recovery units, and similar equipment.
 - g. Fans, blowers, primary balancing dampers, and mixing boxes.
 - h. Packaged HVAC central-station and zone-type units.
 - i. Tanks and pressure vessels.
 - j. Strainers, filters, water-treatment systems, and similar equipment.
- C. Stenciled Equipment Marker Option: Stenciled markers may be provided instead of laminated-plastic equipment markers, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.
- D. Install equipment signs with screws or permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.
 1. Identify mechanical equipment with equipment markers in the following color codes:
 - a. **Green:** For cooling equipment and components.
 - b. **Yellow:** For heating equipment and components.
 - c. **Green and Yellow:** For combination cooling and heating equipment and components.
 - d. **Brown:** For energy-reclamation equipment and components.
 2. Letter Size: Minimum 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 3. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
 4. Include signs for the following general categories of equipment:
 - a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
 - b. Fuel-burning boilers.
 - c. Pumps, compressors, chillers, condensers, and similar motor-driven units.
 - d. Heat exchangers, coils, evaporators, heat recovery units, and similar equipment.
 - e. Fans, blowers, primary balancing dampers, and mixing boxes.
 - f. Packaged HVAC central-station and zone-type units.
 - g. Tanks and pressure vessels.
 - h. Strainers, filters, water-treatment systems, and similar equipment.

- E. Stenciled Equipment Sign Option: Stenciled signs may be provided instead of laminated-plastic equipment signs, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.
- F. Install access panel markers with screws on equipment access panels.

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, less than 6 Inches (150 mm): Pre-tensioned pipe markers. Use size to ensure a tight fit.
 - 2. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.
- B. Stenciled Pipe Marker Option: Stenciled markers may be provided instead of manufactured pipe markers, at Installer's option. Install stenciled pipe markers with painted, color-coded bands or rectangles complying with ASME A13.1 on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- C. 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 (15 m) along each run. Reduce intervals to 25 feet (7.6 m) 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-, relief-, return-, and mixed-air ducts.
 - 4. **ASME A13.1 Colors and Designs:** For hazardous material exhaust.
 - 5. **Letter Size:** Minimum 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm).

mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

- B. Stenciled Duct Marker Option: Stenciled markers, showing service and direction of flow, may be provided instead of laminated-plastic duct markers, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.
- C. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

- A. 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. Cold Water: 1-1/2 inches (38 mm) round.
 - b. Hot Water: 1-1/2 inches (38 mm) round.
 - c. Fire Protection: 1-1/2 inches (38 mm) round.
 - d. Gas: 1-1/2 inches (38 mm) round.
 - 2. Valve-Tag Color:
 - a. Cold Water: Blue.
 - b. Hot Water: Orange.
 - c. Fire Protection: Red.
 - d. Gas: Yellow.
 - 3. Letter Color:
 - a. Cold Water: Black.
 - b. Hot Water: Black.
 - c. Fire Protection: Black.
 - d. Gas: Black.

3.6 VALVE-SCHEDULE INSTALLATION

- A. Mount valve schedule on wall in accessible location in each major equipment room.

3.7 WARNING-TAG INSTALLATION

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

3.8 ADJUSTING

- A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.9 CLEANING

- A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION

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SECTION 15081

DUCT INSULATION

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by this Section.

1.2 SUMMARY

- A. This Section includes semi-rigid and flexible duct, plenum, and breeching insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.
- B. Related Sections include the following:
 - 1. Division 7 Section "Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
 - 2. Section 15083 "Pipe Insulation" for insulation for piping systems.
 - 3. Section 15815 "Metal Ducts" for duct liner.

1.3 SUBMITTALS

- A. General: See Division 1 for general submittal and product substitution requirements.
- B. Pre-construction Shop Drawings: Show fabrication and installation details for metal ducts as follows prior to commencing with fabrication and installation:
 - 1. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
 - 2. Shop Drawings: Show fabrication and installation details for the following:
 - a. Application of field-applied jackets.
 - b. Applications at linkages for control devices.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate clearance requirements with duct installer for insulation application.

1.7 SCHEDULING

- A. Schedule insulation application after testing duct systems. Insulation application may begin on segments of ducts that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed below.
- B. Fiber Glass Insulation:
 - 1. CertainTeed.
 - 2. Knauf FiberGlass.
 - 3. Owens-Corning Fiberglas Corp.
 - 4. Schuller International, Inc. / Johns Manville Insulations

2.2 INSULATION MATERIALS

- A. Fiber Glass Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket (FSK) manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film. 'K' value: 0.24 Btu*in/(hr*sqft*degree F) at 75 degree F. Based on Johns Manville 800 Series Spin-Glas.
- B. Fiberglass Blanket Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket (FSK) manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film. 'K' value: 0.29 Btu*in/(hr*sqft*degree F) at 75 degree F. Based on Johns Manville Microlite.

2.3 FIELD-APPLIED JACKETS

- A. General: ASTM C 921, Type 1, unless otherwise indicated.
- B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.
- C. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209 (ASTM B 209M), and having an integrally bonded moisture barrier over entire surface in contact with insulation. Metal thickness and corrugation dimensions are scheduled at the end of this Section.
 - 1. Finish: Corrugated.
 - 2. Moisture Barrier: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.

2.4 ACCESSORIES AND ATTACHMENTS

- A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd. (270 g/sq. m).
 - 1. Tape Width: 4 inches (100 mm).
- B. Bands: 3/4 inch (19 mm) wide:
 - 1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch (0.5 mm) thick.
- C. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.
 - 1. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperatures of ducts, plenums, and breechings; and to achieve a holding capacity of 100 lb (45 kg) for direct pull perpendicular to the adhered surface.

2.5 VAPOR RETARDERS

- A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

3.3 GENERAL 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 the thickness 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 attack 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-retardant mastic on insulation indicated to receive a vapor retardant.
- 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. Apply insulation over fittings and specialties, with continuous thermal and vapor-retardant integrity, unless otherwise indicated.

- J. Hangers and Anchors: Where vapor retardant is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retardant mastic. Apply insulation continuously through hangers and around anchor attachments.
- K. Insulation Terminations: For insulation application where vapor retardants are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant.
- L. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.
 - 2. Joints and Seams: Cover with tape and vapor retardant as recommended by insulation material manufacturer to maintain vapor seal.
 - 3. Vapor-Retardant Mastics: Where vapor retardants are indicated, apply mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- M. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
- N. Install vapor-retardant mastic on ducts and plenums scheduled to receive vapor retardants.
 - 1. Ducts with Vapor Retardants: Overlap insulation facing at seams and seal with vapor-retardant mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retardant seal.
 - 2. Ducts without Vapor Retardants: Overlap insulation facing at seams and secure with outward clinching staples and pressure-sensitive tape having same facing as insulation.
- 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. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.
 - 1. For insulation indicated to have vapor retardants, taper termination and seal insulation ends with vapor-retardant mastic.

3.4 FIBER GLASS INSULATION APPLICATION

- A. Blanket Applications for Ducts and Plenums: Secure blanket insulation with adhesive and anchor pins and speed washers.
 - 1. Install anchor pins and speed washers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions larger than 24 inches (450 mm). Space 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints.

- Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
 - b. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - c. Do not overcompress insulation during installation.
 2. Impale insulation over anchors and attach speed washers.
 3. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch (13-mm) staples, 1 inch (25 mm) o.c., and cover with pressure-sensitive tape having same facing as insulation.
 5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. Secure with steel band at end joints and spaced a maximum of 18 inches (450 mm) o.c.
 6. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Apply insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6-inch- (150-mm-) wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches (150 mm) o.c.
 8. Apply vapor-retardant mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retardant.
 9. Terminate insulation around duct access doors and seal insulation edges.
 - B. Board Applications for Ducts and Plenums: Secure board insulation with adhesive and anchor pins and speed washers.
 1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Space anchor pins as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm). Space 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
 - c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 4. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch (13-mm) staples, 1 inch (25 mm) o.c., and cover with pressure-sensitive tape having same facing as insulation.
6. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Apply insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6-inch- (150-mm-) wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches (150 mm) o.c.
8. Apply vapor-retardant mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retardant.
9. Terminate insulation around duct access doors and seal insulation edges.

3.5 FIELD-APPLIED JACKET APPLICATION

- A. Apply glass-cloth jacket, where indicated, directly over bare insulation or insulation with factory-applied jackets.
 1. Apply jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of jacket manufacturer's recommended adhesive.
 3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

3.6 DUCT SYSTEM APPLICATIONS

- A. Insulation materials and thickness are specified in schedules at the end of this Section.
- B. Materials and thickness for systems listed below are specified in schedules at the end of this Section.
- C. Insulate the following plenums and duct systems:
 1. Supply ductwork except where located in conditioned space.
 2. Return and relief ductwork in mechanical rooms and in unconditioned space.
 3. Exhaust ductwork within 10 feet of exterior opening.
 4. Outdoor exposed supply and return ductwork.
 5. Boiler breeching.
 6. Outdoor air intake and combustion air ductwork.
- D. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 1. Metal ducts with duct liner.

2. Factory-insulated flexible ducts.
3. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.
4. Flexible connectors.
5. Vibration-control devices.
6. Testing agency labels and stamps.
7. Nameplates and data plates.
8. Access panels and doors in air-distribution systems.

3.7 INDOOR DUCT AND PLENUM APPLICATION SCHEDULE

- A. Service: Rectangular and round, supply-air ducts, above ceilings, concealed, in mechanical rooms, and in unconditioned space.
1. Material: Fiberglass blanket or fiberglass board.
 2. Thickness: 1-½ inches.
 3. Number of Layers: one.
 4. Factory-Applied Jacket: FSK or vinyl-film. Vapor retardant required on ducts conveying air below ambient temperature.
- B. Service: Rectangular and round, return-air and relief air ducts, in mechanical rooms and in unconditioned space. Exhaust ducts within 10' of exterior opening.
1. Material: Fiberglass blanket or fiberglass board.
 2. Thickness: 1 inch.
 3. Number of Layers: one.
 4. Factory-Applied Jacket: FSK or vinyl-film.
- C. Service: Rectangular and round, outside-air intake / combustion air ducts.
1. Material: Fiberglass blanket or fiberglass board.
 2. Thickness: 2 inches.
 3. Number of Layers: one.
 4. Field-Applied Jacket: FSK or vinyl-film.
 5. Vapor Retardant Required.
- D. Service: Round boiler breeching.
1. Material: Fiberglass board.
 2. Thickness: 1 inch.
 3. Number of Layers: one.
 4. Field-Applied Jacket: Corrugated aluminum – thickness: .0016 inch (0.40 mm).

END OF SECTION

SECTION 15083

PIPE INSULATION

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by this Section.

1.2 SUMMARY

- A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.
- B. Related Sections include the following:
 - 1. Division 7, Section 07270 "Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
 - 2. Section 15081 "Duct Insulation" for insulation for ducts and plenums.
 - 3. Pipe insulation shields and protection saddles, see appropriate piping section.

1.3 SUBMITTALS

- A. General: See Division 1 for general submittal and product substitution requirements.
- B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.
 - 1. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
 - 2. Shop Drawings: Show fabrication and installation details for the following:
 - a. Application of protective shields, saddles, and inserts at pipe hangers for each type of insulation and hanger.
 - b. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - c. Removable insulation at piping specialties and equipment connections.
 - d. Application of field-applied jackets.

1.4 QUALITY ASSURANCE

- A. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in the appropriate piping section.
- B. Coordinate clearance requirements with piping Installer for insulation application.

1.7 SCHEDULING

- A. Schedule insulation application after testing piping systems and, where required. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed below.
- B. Fiber Glass Insulation:
 - 1. CertainTeed Manson.
 - 2. Knauf FiberGlass GmbH.
 - 3. Owens-Corning Fiberglas Corp.
 - 4. Schuller International, Inc. / Johns Manville Insulations
- C. Flexible Elastomeric Thermal Insulation:
 - 1. Armstrong World Industries, Inc.
 - 2. Rubatex Corp.

2.2 INSULATION MATERIALS

- A. Fiber Glass Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
1. Thermal conductivity: 0.23 Btu*in/(hr*sq ft*degree F) at 75 degrees F.
 2. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retardant jacket complying with ASTM C 1136. Based on Johns Manville Micro-Lok.
 3. Blanket Insulation: Comply with ASTM C 553, Type II, without facing.
 4. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:
 - a. Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
 - b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.
 5. Vapor-Retardant Mastics: Fire- and water-resistant, vapor-retardant mastic for indoor applications. Comply with MIL-C-19565C, Type II.
- B. Flexible Elastomeric Thermal Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
1. Thermal conductivity: 0.27 Btu*in/(hr*sq ft*degree F) at 75 degrees F.
 2. Adhesive: As recommended by insulation material manufacturer.
 3. Ultraviolet-Protective Coating: As recommended by insulation manufacturer.
 4. Based on Armstrong AP Armaflex.
- C. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.3 FIELD-APPLIED JACKETS

- A. General: ASTM C 921, Type 1, unless otherwise indicated.
- B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.
- C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils (0.5 mm) thick; roll stock ready for shop or field cutting and forming.
1. Adhesive: As recommended by insulation material manufacturer.
 2. PVC Jacket Color: White.

- D. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil- (0.5-mm-) thick, high-impact, ultraviolet-resistant PVC.
 - 1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
 - 2. Adhesive: As recommended by insulation material manufacturer.
- E. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming to indicated sizes. Comply with ASTM B 209 (ASTM B 209M), 3003 alloy, and H-14 temper.
 - 1. Finish and Thickness: Corrugated finish, 0.010 inch (0.25 mm) thick.
 - 2. Moisture Barrier: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
 - 3. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

2.4 ACCESSORIES AND ATTACHMENTS

- A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8-oz. /sq. yd. (270 g/sq. m).
 - 1. Tape Width: 4 inches (100 mm).
- B. Bands: 3/4 inch (19 mm) wide, in one of the following materials compatible with jacket:
 - 1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch (0.5 mm) thick.

2.5 VAPOR RETARDANTS

- A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.
- E. Apply multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Seal joints and seams with vapor-retardant mastic on insulation indicated to receive a vapor retardant.
- H. Keep insulation materials dry during application and finishing.
- I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- J. Apply insulation with the least number of joints practical.
- K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retardant integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.
- L. Hangers and Anchors: Where vapor retardant is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retardant mastic.
 - 1. Apply insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor retardants are indicated, extend insulation on anchor legs at least 12 inches (300 mm) from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant.
 - 3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to the insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

- M. Insulation Terminations: For insulation application where vapor retardants are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant.
- N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.
- O. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.
 - 2. Circumferential Joints: Cover with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches (100 mm) o.c.
 - 3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches (40 mm). Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches (100 mm) o.c.
 - a. Exception: Do not staple longitudinal laps on insulation having a vapor retardant.
 - 4. Vapor-Retardant Mastics: Where vapor retardants are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
 - 5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retardant mastic.
- P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.
 - 1. Seal penetrations with vapor-retardant mastic.
 - 2. Apply insulation for exterior applications tightly joined to interior insulation ends.
 - 3. Extend metal jacket of exterior insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 - 4. Seal metal jacket to roof flashing with vapor-retardant mastic.
- Q. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retardant mastic.
- R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.
- S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section 07270 "Firestopping."
- T. Floor Penetrations: Apply insulation continuously through floor assembly.
 - 1. For insulation with vapor retardants, seal insulation with vapor-retardant mastic where floor supports penetrate vapor retardant.

3.4 FIBER GLASS INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.
2. Where vapor retardants are indicated, seal longitudinal seams and end joints with vapor-retardant mastic. Apply vapor retardant to ends of insulation at intervals of 15 to 20 feet (4.5 to 6 m) to form a vapor retardant between pipe insulation segments.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets with vapor retardants, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retardant mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Apply canvas jacket material with manufacturer's recommended adhesive; overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retardant mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to the written instructions of the manufacturer.
2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with standard PVC fitting covers.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
3. Apply insulation to flanges as specified for flange insulation application.
4. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retardant mastic.
5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 FLEXIBLE ELASTOMERIC THERMAL INSULATION APPLICATION

- A. Apply insulation to straight pipes and tubes as follows:
 - 1. Follow manufacturer's written instructions for applying insulation.
 - 2. Seal longitudinal seams and end joints with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

- B. Apply insulation to flanges as follows:
 - 1. Apply pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of the same thickness as pipe insulation.
 - 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

- C. Apply insulation to fittings and elbows as follows:
 - 1. Apply mitered sections of pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

- D. Apply insulation to valves and specialties as follows:
 - 1. Apply preformed valve covers manufactured of the same material as pipe insulation and attached according to the manufacturer's written instructions.
 - 2. Apply cut segments of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, fabricate removable sections of insulation arranged to allow access to strainer basket.
 - 3. Apply insulation to flanges as specified for flange insulation application.
 - 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

3.6 FIELD-APPLIED JACKET APPLICATION

- A. Foil and Paper Jackets: Apply foil and paper jackets where indicated.
 - 1. Draw jacket material smooth and tight.
 - 2. Apply lap or joint strips with the same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Apply jackets with 1-1/2-inch (40-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retardant jackets and exposed insulation with vapor-retardant mastic.

- B. Apply PVC jacket where indicated, with 1-inch (25-mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
 - 1. Provide PVC jacket on insulation below 10 feet in mechanical rooms.
 - 2. Provide PVC jacket on insulation exposed in occupied spaces.
- C. Apply metal jacket where indicated, with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

3.7 FINISHES

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of the insulation manufacturer's recommended protective coating.

3.8 PIPING SYSTEM APPLICATIONS

- A. Insulation materials and thickness are specified in schedules at the end of this Section.
- B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 - 1. Flexible connectors.
 - 2. Vibration-control devices.
 - 3. Fire-suppression piping.
 - 4. Drainage piping located in crawl spaces, unless otherwise indicated.
 - 5. Below-grade piping, unless otherwise indicated.
 - 6. Chrome-plated pipes and fittings, unless potential for personnel injury.
 - 7. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.
 - 8. Flanges and unions at equipment on hot piping systems conveying fluids 140 degrees F or less. Bevel and seal ends of insulation.

3.9 INSULATION APPLICATION SCHEDULE, GENERAL

- A. Refer to insulation application schedules for required insulation materials, vapor retardants, and field-applied jackets.
- B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.10 INSULATION APPLICATION SCHEDULE

- A. Service: Domestic hot water.
 - 1. Operating Temperature: 60 to 140 deg F (15 to 60 deg C).

2. Insulation Material: Fiberglass with jacket (Jacket to be PVC if exposed in occupied spaces.).
 3. Insulation Thickness: Apply the following insulation thickness:
 - a. Piping up to 1 1/4": 0.5" thickness.
 - b. Piping 1-1/4" and greater: 1" thickness.
 4. Vapor Retardant Required: No.
 5. Finish: None.
- B. Service: Domestic cold water:
1. Operating Temperature: 35 to 60 deg F (2 to 15 deg C).
 2. Insulation Material: Fiberglass with jacket (Jacket to be PVC if exposed in occupied spaces.).
 3. Insulation Thickness: Apply the following insulation thickness:
 - a. Piping up to 1 1/4": 0.5" thickness.
 - b. Piping 1-1/4" and greater: 1" thickness.
 4. Vapor Retardant Required: Yes.
 5. Finish: None.
- C. Service: Condensate drain piping from cooling coils.
1. Operating Temperature: 35 to 75 deg F (2 to 24 deg C).
 2. Insulation Material: Flexible elastomeric.
 3. Insulation Thickness: 1/2".
 4. Vapor Retardant Required: No
 5. Finish: none.
- D. Service: Refrigerant suction and hot-gas piping.
1. Operating Temperature: 40 to 60 deg F (2 to 10 deg C).
 2. Insulation Material: Flexible elastomeric.
 3. Insulation Thickness: Apply the following insulation thickness:
 - a. All piping: 1" thickness.
 4. Finish:
 - a. Indoors: none.
 - b. Outdoors: Corrugated aluminum jacket with seams at bottom banded at 12" O.C.
- E. Service: Heating hot-water supply and return.
1. Operating Temperature: 100 to 200 deg F (38 to 93 deg C).
 2. Insulation Material: Fiberglass with jacket (Jacket to be PVC if exposed in occupied spaces.).
 3. Insulation Thickness: Apply the following insulation thickness:
 - a. Piping up to 4": 1.0" thickness.
 - b. Piping 4" and greater: 1.5" thickness.

- c. Piping insulation is not required between the control valve and coil on run-outs when the control valve is located within 4 feet of the coil and the pipe size is 1 inch or less.
- 4. Vapor Retardant Required: No.
- 5. Finish: none.

END OF SECTION

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SECTION 15122

METERS AND GAGES

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following meters and gages for mechanical systems:
 - 1. Thermometers.
 - 2. Gages.
- B. Related Sections include the following:
 - 1. Division 15, Section 15140 "Plumbing Piping and Specialties" for domestic and fire-protection water service meters inside the building.

1.4 SUBMITTALS

- A. General: See Division 1 for general submittal and product substitution requirements.
- B. Product Data: For each type of product indicated include performance curves.
- C. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed below.

- B. Metal-case, liquid-in-glass thermometers:
 - 1. Terrice, H. O. Co.
 - 2. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- C. Bimetallic-actuated dial thermometers
 - 1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
 - 2. Terrice, H. O. Co.
 - 3. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- D. Thermowells
 - 1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
 - 2. Terrice, H. O. Co.
 - 3. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- E. Pressure gages
 - 1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
 - 2. Terrice, H. O. Co.
 - 3. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

2.2 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

- A. Case: Die-cast aluminum, 9 inches long.
- B. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.
- C. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- D. Window: Plastic.
- E. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- F. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
- G. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.3 BIMETALLIC-ACTUATED DIAL THERMOMETERS

- A. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.
- B. Case: Liquid-filled type, stainless steel with 3-inch diameter.

- C. Element: Bimetal coil.
- D. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Pointer: Red or other dark-color metal.
- F. Window: Glass.
- G. Ring: Stainless steel.
- H. Connector: Adjustable angle type.
- I. Stem: Metal, for thermowell installation and of length to suit installation.
- J. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.4 THERMOWELLS

- A. Manufacturers: Same as manufacturer of thermometer being used or see list of acceptable manufacturers above.
- B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.5 PRESSURE GAGES

- A. Direct Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
 - 1. Case: Liquid-filled type, plastic, 6-inch diameter.
 - 2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
 - 3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
 - 4. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 - 6. Pointer: Red or other dark-color metal.
 - 7. Window: Plastic.
 - 8. Ring: Plastic.
 - 9. Accuracy: Grade 2A, plus or minus 1/2 percent of middle half scale.
 - 10. Pressure Range: 0 to 100 psig of pressure.
 - 11. Range for Fluids under Pressure: Two times operating pressure.
- B. Pressure-Gage Fittings:
 - 1. Valves: NPS 1/4 brass or stainless steel needle type.
 - 2. Siphons: NPS 1/4 coil of brass tubing with threaded ends.

3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

- A. Install liquid-in-glass thermometers in the following locations:
 1. Inlet and outlet of hydronic boiler.
 2. Inlet and outlet of each hydronic coil in air-handling units.
- B. Install liquid-filled-case-type, bimetallic-actuated dial thermometers at suction and discharge of each pump.
- C. Provide the following temperature ranges for thermometers:
 1. Domestic Hot Water: 30 to 180 deg F, with 2-degree scale divisions.
 2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.
 3. Heating Hot Water: 30 to 240 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

- A. Install liquid-filled-case-type pressure gages at suction and discharge of each pump.

3.3 INSTALLATIONS

- A. Install direct-mounting thermometers and adjust vertical and tilted positions.
- B. Install thermowells with socket extending a minimum of 2 inches into fluid or one-third of diameter of pipe and in vertical position in piping tees where thermometers are indicated.
- C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

3.4 CONNECTIONS

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

3.5 ADJUSTING

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

END OF SECTION

SECTION 15140

PLUMBING PIPING

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following piping systems to a point 10-feet outside the building wall, unless otherwise noted;
 - 1. Water Supply Piping.
 - a. Domestic Cold and Hot Water.
 - 2. Drainage, Waste and Vent, (DWV).
 - a. Sanitary Waste and Vent.
- B. Related Sections include the following:
 - 1. Division 2 Sections for site utility service piping to a point 10-feet outside the building.
 - 2. Section 15060, "Hangers and Supports" for pipe supports, above AND BELOW slab.
 - 3. Section 15071, "Mechanical Vibration and Seismic Control"
 - 4. Section 15083, "Pipe Insulation" for system insulation requirements.
 - 5. Section 15122, "Meters and Gauges" for thermometers, pressure gages, and fittings.
 - 6. Section 15430, "Plumbing Specialties" for water distribution piping specialties.

1.3 DEFINITIONS

- A. PVC: Polyvinyl chloride plastic.
- B. CLDI: Cement Lined Ductile Iron.

- C. DWV: Drainage, Waste and Vent piping systems.

1.4 PERFORMANCE REQUIREMENTS

- A. Provide components and installations capable of producing piping systems with the following minimum working pressure ratings, unless otherwise noted.
 - 1. Water Supply Systems, Above Ground: 125 psig.
 - 2. Water Supply Systems, Below Ground: 150 psig.
 - 3. DWV, (Gravity) Systems: 10 foot of head of water.
 - 4. DWV, (Forced Main) Systems: 50 psig.

1.5 SUBMITTALS

- A. General: See Division 1 for general submittal and product substitution requirements.
- B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.
 - 1. Product Data: For pipe, tube, fittings, valves and couplings.
- C. Submittals During Construction: Submit the following items at the intervals indicated.
 - 1. Pressure test results after system rough-ins.
 - a. Test results to include Plumbing Inspector sign-off.
 - b. If systems are tested in portions, submit results as each portion is tested.
- D. Post Construction Submittals: Submit the following items upon completion of system installations.
 - 1. Water Disinfection statement and final water quality test results.
 - 2. Final Plumbing Inspector Sign-off.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed below.
- B. No-hub Couplings:
 - 1. Husky Technologies.
 - 2. Tyler Pipe Co.
 - 3. Charlotte Pipe and Foundry.

C. Ball Valves:

1. Conbraco Industries, Inc.; Apollo Div.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Div.
4. NIBCO INC.
5. Watts Industries, Inc.; Water Products Div.
6. Hammond Valve.
7. Milwaukee Valve Company.

D. Gate Valves:

1. Crane Co.; Crane Valve Group; Stockham Div.
2. Grinnell Corporation.
3. Hammond Valve.
4. Milwaukee Valve Company.
5. NIBCO INC.
6. Watts Industries, Inc.; Water Products Div.

E. Globe Valves:

1. Crane Co.; Crane Valve Group; Stockham Div.
2. Grinnell Corporation.
3. Hammond Valve.
4. Milwaukee Valve Company.
5. NIBCO INC.

F. Swing Check Valves:

1. Crane Co.; Crane Valve Group; Stockham Div.
2. Grinnell Corporation.
3. Hammond Valve.
4. Milwaukee Valve Company.
5. NIBCO INC.
6. Watts Industries, Inc.; Water Products Div.

2.2 PIPING MATERIALS

- A. Refer to Part 3 "Pipe and Fitting Applications" Article for applications of pipe, tube, fitting, and joining materials.
- B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.3 DUCTILE IRON PIPE AND FITTINGS

- A. Cement-Lined, Mechanical-Joint, Ductile-Iron Pipe, (CLDI): AWWA C151, with mechanical-joint, bell- and plain-spigot ends, AWWA C205 cement-mortar lining.
 - 1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern, AWWA C205 cement-mortar lining.
 - a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- B. Cement-Lined, Push-on-Joint, Ductile-Iron Pipe, (CLDI): AWWA C151, with push-on-joint, bell- and plain-spigot ends, AWWA C205 cement-mortar lining.
 - 1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern, AWWA C205 cement-mortar lining.
 - a. Gaskets: AWWA C111, rubber.
 - b. Restraints: push-on joints to include pipe clamp and tie-rod reinforcement.

2.4 COPPER TUBE AND FITTINGS

- A. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- B. Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
 - 4. Copper, Grooved-End Fittings: ASTM B 75 copper tube or ASTM B 584 bronze castings.
 - a. Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, gasket suitable for hot water, and bolts and nuts.
- C. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
 - 1. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

2.5 CAST-IRON SOIL PIPE AND FITTINGS

- A. Hub-and-Spigot Pipe and Fittings: ASTM A 74, Service class.
 - 1. Gaskets: ASTM C 564, rubber.
- B. Hubless Pipe and Fittings: ASTM A 888 or CISPI 301.
 - 1. Couplings: ASTM C 1277 assembly of metal housing, corrosion-resistant fasteners, and ASTM C 564 rubber sleeve with integral, center pipe stop.
 - a. Heavy-Duty, Type 304, Stainless-Steel Couplings: ASTM A 666, Type 304, stainless-steel shield; stainless-steel bands; and sleeve.
 - 1) NPS 1-1/2 to NPS 4: 3-inch wide shield with 4 bands.
 - 2) NPS 5 to NPS 10: 4-inch wide shield with 6 bands.

2.6 PVC PIPE AND FITTINGS

- A. PVC Schedule 40 Pipe: ASTM D 1785.
 - 1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

2.7 VALVES

- A. Balancing and drain valves are specified in Division 15 Section "Plumbing Specialties."
- B. Refer to Part 3 "Valve Applications" Article for applications of valve types.
- C. General Requirements:
 - 1. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
 - 2. Valve Sizes: Same as upstream pipe, unless otherwise indicated.
 - 3. Handwheel: For valves other than quarter-turn types.
 - 4. Lever Handle: For quarter-turn valves NPS 6 (DN 150) and smaller.
 - 5. Extended Valve Stems: On insulated valves.
 - 6. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.
 - 7. Valve Grooved Ends: AWWA C606, NPS 2-1/2 (DN 65) and larger.
 - 8. Solder Joint: With sockets according to ASME B16.18.
 - a. Caution: Use solder with melting point below 840 deg F (454 deg C) for angle, check, gate, and globe valves below 421 deg F (216 deg C) for ball valves.
 - 9. Threaded: With threads according to ASME B1.20.1.
 - 10. Valve Bypass and Drain Connections: MSS SP-45.
- D. Ball Valves:

1. MSS SP-110, 600# W.O.G., forged brass, two piece body, hard chrome plated forged brass ball, standard or full port, true adjustable packing nut, (O-ring only type stem seal not acceptable) blow-out proof stem.
 2. Acceptable end connections;
 - a. Threaded for NPS 4 and smaller.
 - b. Soldered for NPS 3 and smaller.
 - c. Flanged or grooved for NPS 4 and larger.
 3. Basis of Design: Apollo 70 Series.
- E. Gate Valves:
1. MSS SP-80, Class 125, bronze body, bronze trim, rising stem, hand wheel, inside screw, solid wedge disc.
 2. Acceptable end connections;
 - a. Soldered for NPS 3 and smaller.
- F. Globe Valves:
1. MSS SP-80, Class 125, bronze body, bronze trim, bronze disc.
 2. Acceptable end connections;
 - a. Soldered for NPS 3 and smaller.
- G. Swing Check Valves:
1. Up to NPS 3: MSS SP-80, Class 125, bronze body and cap, bronze swing disc with rubber seat.
 2. NPS 4 and larger: MSS SP-71, Class 125, iron body, bronze swing disc, renewable disc seal and seat.
 3. Acceptable end connections;
 - a. Soldered for NPS 3 and smaller.
 - b. Flanged or grooved for NPS 4 and larger.

PART 3 - EXECUTION

3.1 EXCAVATION AND PREPARATION

- A. Excavating, trenching, and backfilling are specified in Division 2 Section "Earthwork."
- B. Prepare pipe bedding to receive buried piping.
 1. Grade the bottom of the trench smooth. Provide a stable, rock free base.
 2. Remove any unstable materials from the base of the trench. Provide sand or pea stone as required to grade the trench bottom.
 3. Remove base materials at each piping joint to relieve undo stresses at the fittings and couplings.

3.2 PIPE AND FITTING APPLICATIONS

- A. Underground and Under Building Slab, Water-Service Piping to 10-feet outside the building wall:
 - 1. NPS ½ to NPS 2-1/2: Soft copper tube, Type K, no fittings or joints allowed.
 - 2. NPS 3 to NPS 8: Cement-lined ductile iron pipe; mechanical or bell and spigot fittings; mechanical or restrained push-on joints.
 - B. Water Supply Piping, Aboveground:
 - 1. Hard copper tube, Type L; copper pressure fittings; lead-free soldered joints.
 - a. Option for NPS 2-1/2 and larger: Hard copper tube, Type L with grooved ends; copper grooved-end fittings and couplings; and grooved joints.
 - C. DWV Gravity Piping, Below Building Slab and to 10-feet outside the building wall:
 - 1. Service weight cast iron soil pipe; hub and spigot fittings, gasket or lead and oakum joints.
 - a. Option: Schedule 40 PVC pipe; drainage pattern PVC socket fittings; solvent cement joints.
 - D. DWV Gravity Piping, Aboveground:
 - 1. Service weight cast iron soil pipe; hubless cast iron fittings, no-hub coupled joints.
 - 2. Option: 2-inch and smaller drain and vent lines may be installed using Copper tube, Type DWV; copper drainage fittings, soldered joints.
 - 3. Lab sinks (SK-B) shall have the DWV piped with Polypropylene piping (PPP) from the sink to the trap.
 - E. Sub-slab System Piping, Aboveground:
 - 1. Schedule 40 PVC pipe; drainage pattern PVC socket fittings; solvent cement joints.
 - F. Forced Main DWV Piping, Above/belowground:
 - 1. Hard copper tube, Type L; copper pressure fittings; lead-free soldered joints.
- 3.3 VALVE APPLICATIONS
- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - 1. Shutoff Duty: Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use gate valves for piping NPS 2-1/2 (DN 65) and larger.
 - 2. Directional Duty: Use swing check valves.
 - 3. Hot-Water-Piping, Balancing Duty: Memory-stop balancing valves.
 - 4. Drain Duty: Hose-end drain valves.
 - B. Cast-iron, grooved-end valves may be used with grooved-end piping.

- C. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use gate valves for piping NPS 2-1/2 (DN 65) and larger.
- D. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
 - 1. Install hose-end drain valves at low points in water mains, risers, and branches.
 - 2. Install stop-and-waste drain valves where indicated.
- E. Install balancing valve in each hot-water circulation return branch. Set balancing valves partly open to restrict but not stop flow. Balancing valves are specified in Division 15, Section 15140 "Plumbing piping and Specialties."

3.4 PIPING INSTALLATION

- A. Install under-building-slab copper tubing according to CDA's "Copper Tube Handbook."
- B. Install wall penetration system at each service pipe penetration through foundation wall where piping enters/exits a below grade basement space, (not required for slab-on-grade frost wall penetrations). Make installation watertight.
- C. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.
- D. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
- E. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- F. Make changes in direction for DWV piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- G. Lay buried building DWV piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- H. Install DWV piping at the following minimum slopes, unless otherwise indicated:
 - 1. Horizontal drainage piping, NPS 3-inch and smaller: 1/4-inch per foot downward in direction of flow.

2. Horizontal drainage piping, NPS 4-inch and larger: 1/8-inch per foot downward in direction of flow.
 - a. Exception: Dedicated kitchen waste piping to be pitched at 1/4-inch per foot downward in direction of flow.
3. Vent Piping: 1/8-inch per foot down toward vertical fixture vent or toward vent stack.

- I. Install PVC DWV piping according to ASTM D 2665.
- J. Install underground PVC DWV piping according to ASTM D 2321.
- K. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.5 JOINT CONSTRUCTION

- A. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
- B. Grooved Joints: Assemble joints with grooved-end-pipe or grooved-end-tube coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- C. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.
 2. Hubless Joints: Make with rubber gasket and sleeve or clamp.
- D. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Pipe hanger and support devices are specified in Division 15, Section 15060 "Hangers and Supports." Install the following:
 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet (30 m): MSS Type 49, spring cushion rolls, if indicated.
 3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Install supports according to Division 15, Section 15060 "Hangers and Supports."
- C. Support vertical piping and tubing at base and at each floor.

- D. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch (10 mm).
- E. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
 - 2. NPS 1-1/2: 108 inches with 3/8-inch rod.
 - 3. NPS 2: 10 feet with 3/8-inch rod.
 - 4. NPS 2-1/2: 11 feet with 1/2-inch rod.
 - 5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
- F. Install supports for vertical steel piping every 15 feet.
- G. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
 - 2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 - 4. NPS 2-1/2: 108 inches with 1/2-inch rod.
 - 5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
- H. Install supports for vertical copper tubing every 10 feet.
- I. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 - 2. NPS 3: 60 inches with 1/2-inch rod.
- J. Install supports for vertical cast-iron soil piping every 15 feet.
- K. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 2 and Smaller: 48 inches with 3/8-inch rod.
 - 2. NPS 2-1/2 to NPS 3-1/2: 48 inches with 1/2-inch rod.
- L. Install supports for vertical PVC piping every 48 inches.
- M. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment and machines to allow service and maintenance.

- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
- D. Connect domestic water piping to the following:
 - 1. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 15; Section 15400 "Plumbing Fixtures."
 - 2. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.
- E. Connect DWV piping to exterior sanitary and storm piping. Use transition fitting to join dissimilar piping materials.
- F. Connect drainage and vent piping to the following:
 - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 15; Section 15410 "Plumbing Fixtures."
 - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 15; Section 15430 "Plumbing Specialties."
 - 4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.
- G. Connect interior storm drainage piping to sump pump and sump pump discharge piping to the exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

3.8 FIELD QUALITY CONTROL

- A. Inspect domestic water piping as follows:
 - 1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - 2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
 - 3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- B. Test domestic water piping as follows:
1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
 6. Prepare reports for tests and required corrective action.
- C. Inspect DWV piping as follows:
1. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - b. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
 2. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
 3. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test DWV piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.9 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - a. Adjust calibrated balancing valves to flows indicated.
5. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.10 CLEANING

A. General: Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

B. Clean and disinfect potable and non-potable domestic water piping as follows:

1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.

- d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
 3. Prepare and submit reports of purging and disinfecting activities.
- C. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- D. Place plugs in ends of uncompleted piping at end of day and when work stops.

- END OF SECTION

SECTION 15181

HYDRONIC PIPING

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes piping, and hydronic specialties for hot-water heating, and makeup water for this system.
- B. Related Sections include the following:
 - 1. Division 15, Section 15060 "Hangers and Supports" for pipe supports, product descriptions, and installation requirements. Hanger and support spacing is specified in this Section.
 - 2. Division 15, Section 15071, "Mechanical Vibration and Seismic Control"
 - 3. Division 15, Section 15122 "Meters and Gages" for thermometers, flow meters, and pressure gages.
 - 4. Division 15, Section 15185 "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.
 - 5. Division 15, Section 15900 "HVAC Instrumentation and Controls" for temperature-control valves and sensors.

1.3 SUBMITTALS

- A. Welding Certificates: Copies of certificates for welding procedures and personnel.
- B. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Failed test results and corrective action taken to achieve requirements.

- C. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

- A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.5 COORDINATION

- A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate pipe sleeve installations for foundation wall penetrations.
- C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7.
- D. Coordinate pipe fitting pressure classes with products specified in related Sections.
- E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 for fire and smoke wall and floor assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Grooved Mechanical-Joint Fittings and Couplings:
 - a. Central Sprinkler Company; Central Grooved Piping Products.
 - b. Grinnell Corporation.
 - c. Victaulic Company of America.
 - 2. Calibrated Balancing Valves:

- a. Armstrong Pumps, Inc.
 - b. Flow Design, Inc.
 - c. Gerand Engineering Company.
 - d. Griswold Controls.
 - e. ITT Bell & Gossett; ITT Fluid Technology Corp.
 - f. Taco, Inc.
3. Pressure-Reducing Valves:
- a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Conbraco Industries, Inc.
 - d. ITT Bell & Gossett; ITT Fluid Technology Corp.
 - e. Spence Engineering Company, Inc.
 - f. Watts Industries, Inc.; Watts Regulators.
4. Safety Valves:
- a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Conbraco Industries, Inc.
 - d. ITT McDonnell & Miller Div.; ITT Fluid Technology Corp.
 - e. Kunkle Valve Division.
 - f. Spence Engineering Company, Inc.
5. Automatic Flow-Control Valves:
- a. Flow Design, Inc.
 - b. Griswold Controls.
6. Expansion Tanks:
- a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. ITT Bell & Gossett; ITT Fluid Technology Corp.
 - d. Taco, Inc.
7. Air Separators and Air Purgers:
- a. Spirovent
 - b. Armstrong Pumps, Inc.
 - c. ITT Bell & Gossett; ITT Fluid Technology Corp.
 - d. Taco, Inc.
- 2.2 PIPING MATERIALS
- A. COPPER TUBE AND FITTINGS
1. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

2. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
3. DWV Copper Tubing: ASTM B 306, Type DWV.
4. Wrought-Copper Fittings: ASME B16.22.
5. Wrought-Copper Unions: ASME B16.22.
6. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.
7. Brazing Filler Metals: AWS A5.8, Classification B Ag-1 (silver).

B. STEEL PIPE AND FITTINGS

1. Steel Pipe, NPS 2 and Smaller: ASTM A 53, Type S (seamless) or Type F (furnace-butt welded), Grade B, Schedule 40, black steel, plain ends.
2. Steel Pipe, NPS 2-1/2 through NPS 12: ASTM A 53, Type E (electric-resistance welded), Grade B, Schedule 40, black steel, plain ends.
3. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53, Schedule 40, black steel; seamless for NPS 2 and smaller and electric-resistance welded for NPS 2-1/2 and larger.
4. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250.
5. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.
6. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.
7. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.
8. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
9. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
10. Material Group: 1.1.
11. End Connections: Butt-welding.
12. Facings: Raised face.
13. Grooved Mechanical-Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47, Grade 32510 malleable iron; ASTM A 53, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders designed to accept grooved end couplings.
14. Grooved Mechanical-Joint Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
15. Flexible Connectors: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.
16. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.
17. Packed, Slip, Expansion Joints: 150-psig minimum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, packing ring, packing, limit rods, flanged ends, and chrome-plated finish on slip-pipe telescoping section.
18. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.
19. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

C. VALVES

1. Gate, globe, check, and ball valves are specified in Division 15, Section 15140 "Plumbing Piping and Specialties."
2. Refer to Part 3 "Valve Applications" Article for applications of each valve.
3. Calibrated Balancing Valves, NPS 2 and Smaller: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having threaded ends. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.
4. Calibrated Balancing Valves, NPS 2-1/2 and Larger: Cast-iron or steel body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having flanged or grooved connections. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.
5. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.
6. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.
7. Automatic Flow-Control Valves: Gray-iron body, factory set to maintain constant flow with plus or minus 5 percent over system pressure fluctuations, and equipped with a readout kit including flow meter, probes, hoses, flow charts, and carrying case. Each valve shall have an identification tag attached by chain, and be factory marked with the zone identification, valve number, and flow rate. Valve shall be line size and one of the following designs:
 - a. Gray-iron or brass body, designed for 175 psig at 200 deg F with stainless-steel piston and spring.
 - b. Brass or ferrous-metal body, designed for 300 psig at 250 deg F with corrosion-resistant, tamperproof, self-cleaning, piston-spring assembly easily removable for inspection or replacement.
 - c. Combination assemblies, including bronze ball valve and brass alloy control valve, with stainless-steel piston and spring, fitted with pressure and temperature test valves, and designed for 300 psig at 250 deg F.
8. Plastic Ball Valves: 150-psig working pressure, 250 deg F maximum operating temperature, full port design, 1- or 2-piece body design, CPVC body and ball, polytetrafluoroethylene seats, EPDM seals, and tee handle; with threaded, socket, union, or flanged connections.

D. HYDRONIC SPECIALTIES

1. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.
2. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity by a flexible diaphragm or bladder securely sealed

- into tank. Include drain fitting and taps for pressure gage and air-charging fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Factory fabricate and test tank with taps and supports installed and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
3. Tangential-Type Air Separators: Welded black steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature; perforated stainless-steel air collector tube designed to direct released air into expansion tank; tangential inlet and outlet connections; threaded connections for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger; threaded blowdown connection. Provide units in sizes for full-system flow capacity.
 4. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, threaded connections for NPS 2 and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection.
 5. Flexible Connectors: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged- or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.
 6. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot Water, NPS 2 and Smaller: Aboveground, use Type L drawn-temper copper tubing with soldered joints. Belowground or within slabs, use Type K (Type A) annealed-temper copper tubing with soldered joints. Use the fewest possible joints belowground and within floor slabs.
- B. Hot Water, NPS 2-1/2 and Larger: Schedule 40 steel pipe with welded and flanged joints or grooved mechanical-joint couplings.

3.2 VALVE APPLICATIONS

- A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:
 1. Shutoff Duty: Ball valves.
 2. Throttling Duty: Ball valves.
- B. Install shutoff duty valves at each branch connection to supply and return mains, at supply/return connection to each piece of equipment, unless only one piece of equipment is connected in the branch line.
- C. Install calibrated balancing valves in the return water line of each heating element and elsewhere as required to facilitate system balancing. This balancing valve does not remove the requirement for a shutoff duty valve on the return water line.

- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.
- F. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

3.3 PIPING INSTALLATIONS

- A. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- B. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- C. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- D. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- E. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.
- F. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- G. Anchor piping for proper direction of expansion and contraction.

3.4 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Division 15, Section 15060 "Hangers and Supports." Comply with requirements below for maximum spacing of supports.
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.

5. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
 2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
 3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
 6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
- D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
- E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install in-line air separators in pump suction lines. Install piping to compression tank with a 2 percent upward slope toward tank. Install drain valve on units NPS 2 and larger.
- C. Install expansion tanks on floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. Size for supply and return piping connections shall be same as for equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install ports for pressure and temperature gages at coil inlet connections.

3.7 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 1. Leave joints, including welds, uninsulated and exposed for examination during test.

2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
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 trapped air. Use drains installed at low points for complete draining of liquid.
3. Check expansion tanks to determine that they are not air bound and that system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of 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.

3.8 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:

1. Open valves to fully open position. Close coil bypass valves.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check air vents at high points of system and determine if all are installed and bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Check operation of automatic bypass valves.
7. Check and set operating temperatures of boilers to design requirements.
8. Lubricate motors and bearings.

3.9 CLEANING

- A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

END OF SECTION

SECTION 15183

REFRIGERANT PIPING

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.
- B. Related Sections include the following:
 - 1. Division 7 Section "Through-Penetration Firestop Systems" for materials and methods for sealing pipe penetrations through fire and smoke barriers.
 - 2. Division 7 Section "Joint Sealants" for materials and methods for sealing pipe penetrations through exterior walls.
 - 3. Division 15 Section "Hangers and Supports" for pipe supports and installation requirements.
 - 4. Division 15 Section "Mechanical Identification" for labeling and identifying refrigerant piping.
 - 5. Division 15 Section "HVAC Instrumentation and Controls" for thermostats, controllers, automatic-control valves, and sensors.

1.3 SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for thermostatic expansion valves, solenoid valves, and pressure-regulating valves.
- B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationship between piping and equipment.

1. Refrigerant piping indicated is schematic only. Size piping and design the actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes, to ensure proper operation and compliance with warranties of connected equipment.
 - C. Welding Certificates: Copies of certificates for welding procedures and personnel.
 - D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- 1.4 QUALITY ASSURANCE
- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX; "Welding and Brazing Qualifications."
 - B. ASHRAE Standard: Comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
 - C. ASME Standard: Comply with ASME B31.5, "Refrigeration Piping."
 - D. UL Standard: Provide products complying with UL 207, "Refrigerant-Containing Components and Accessories, Nonelectrical"; or UL 429, "Electrically Operated Valves."
- 1.5 COORDINATION
- A. Coordinate layout and installation of refrigerant piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
 - B. Coordinate pipe sleeve installations for foundation wall penetrations.
 - C. Coordinate pipe sleeve installations for penetrations in exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for materials and methods for sealing pipe penetrations through fire and smoke barriers.
 - D. Coordinate pipe fitting pressure classes with products specified in related Sections.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Refrigerants:
 - a. Allied Signal, Inc./Fluorine Products; Genetron Refrigerants.
 - b. DuPont Company; Fluorochemicals Div.

- c. Elf Atochem North America, Inc.; Fluorocarbon Div.
- d. ICI Americas Inc./ICI KLEA; Fluorochemicals Bus.

2. Refrigerant Valves and Specialties:

- a. Climate & Industrial Controls Group; Parker-Hannifin Corp.; Refrigeration & Air Conditioning Division.
- b. Danfoss Electronics, Inc.
- c. Emerson Electric Company; Alco Controls Div.
- d. Henry Valve Company.
- e. Sporlan Valve Company.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: ASTM B 280, Type ACR .
- B. Annealed-Temper Copper Tube: ASTM B 280, Type ACR.
- C. Wrought-Copper Fittings: ASME B16.22.
- D. Wrought-Copper Unions: ASME B16.22.
- E. Brazing Filler Metals: AWS A5.8, Classification, BAg-1 (silver)
- F. Flexible Connectors: 500-psig (3450-kPa) minimum operating pressure; seamless tin-bronze core, high-tensile bronze-braid covering, and solder-joint end connections; dehydrated, pressure tested, minimum 7 inches (180mm) long

2.3 VALVES

- A. Diaphragm Packless Valves: 500-psig (3450-kPa) working pressure and 275 deg F (135 deg C) working temperature; globe design with straight-through or angle pattern; forged-brass or bronze body and bonnet, phosphor bronze and stainless-steel diaphragms, rising stem and handwheel, stainless-steel spring, nylon seat disc, and with solder-end connections.
- B. Packed-Angle Valves: 500-psig (3450-kPa) working pressure and 275 deg F (135 deg C) working temperature; forged-brass or bronze body, forged-brass seal caps with copper gasket, back seating, rising stem and seat, molded stem packing, and with solder-end connections.
- C. Check Valves Smaller Than NPS 1 (DN 25): 400-psig (2760-kPa) operating pressure and 285 deg F (141 deg C) operating temperature; cast-brass body, with removable piston, polytetrafluoroethylene seat, and stainless-steel spring; globe design. Valve shall be straight-through pattern, with solder-end connections.
- D. Check Valves, NPS 1 (DN 25) and Larger: 400-psig (2760-kPa) operating pressure and 285 deg F (141 deg C) operating temperature; cast-bronze body, with cast-bronze or forged-brass bolted bonnet; floating piston with mechanically retained polytetrafluoroethylene seat disc. Valve shall be straight-through or angle pattern, with solder-end connections.

- E. Service Valves: 500-psig (3450-kPa) pressure rating; forged-brass body with copper stubs, brass caps, removable valve core, integral ball check valve, and with solder-end connections.
- F. Solenoid Valves: Comply with ARI 760; 250 deg F (121 deg C) temperature rating and 400-psig (2760-kPa) working pressure; forged brass, with polytetrafluoroethylene valve seat, 2-way, straight-through pattern, and solder-end connections; manual operator; fitted with suitable NEMA 250 enclosure of type required by location, with 1/2-inch (16-GRC) conduit adapter and 120-V, normally closed holding coil.
- G. Thermostatic Expansion Valves: Comply with ARI 750; brass body with stainless-steel parts; thermostatic-adjustable, modulating type; size and operating characteristics as recommended by manufacturer of evaporator, and factory set for superheat requirements; solder-end connections; with sensing bulb, distributor having side connection for hot-gas bypass line, and external equalizer line.

2.4 REFRIGERANT PIPING SPECIALITIES

- A. Straight- or Angle-Type Strainers: 500-psig (3450-kPa) working pressure; forged-brass or steel body with stainless-steel wire or brass-reinforced Monel screen of 80 to 100 mesh in liquid lines up to 1-1/8 inches (30 mm), 60 mesh in larger liquid lines, and 40 mesh in suction lines; with screwed cleanout plug and solder-end connections.
- B. Moisture/Liquid Indicators: 500-psig (3450-kPa) maximum working pressure and 200 deg F (93 deg C) operating temperature; all-brass body with replaceable, polished, optical viewing window with color-coded moisture indicator; with solder-end connections.
- C. Replaceable-Core Filter-Dryers: 500-psig (3450-kPa) maximum working pressure; heavy gage protected with corrosion-resistant-painted steel shell, flanged ring and spring, ductile-iron cover plate with steel cap screws; wrought-copper fittings for solder-end connections; with replaceable-core kit, including gaskets and the following:
 - 1. Filter Cartridge: Pleated media with integral end rings, stainless-steel support, ARI 730 rated for capacity.
- D. Permanent Filter-Dryer: 350-psig (2410-kPa) maximum operating pressure and 225 deg F (107 deg C) maximum operating temperature; steel shell and wrought-copper fittings for solder-end connections; molded-felt core surrounded by desiccant.
- E. Mufflers: 500-psig (3450-kPa) operating pressure, welded-steel construction with fusible plug; sized for refrigeration capacity.

2.5 RECEIVERS

- A. Receivers, 6-Inch (150-mm) Diameter and Smaller: ARI 495, UL listed, steel, brazed, 400-psig (2760-kPa) pressure rating, with tappings for inlet, outlet, and pressure relief valve.
- B. Receivers Larger Than 6-Inch (150-mm) Diameter: ARI 495, welded steel, tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII; 400-psig (2760-kPa)

pressure rating, with tapings for liquid inlet and outlet valves, pressure relief valve, and liquid-level indicator.

2.6 REFRIGERANTS

- A. ASHRAE 34, R-22, Chlordifluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Aboveground, within Building: Type L (Type B) drawn-copper tubing.
- B. Aboveground, exterior to the Building: Type K (Type A) annealed-copper tubing.

3.2 VALVE APPLICATIONS

- A. Install diaphragm packless or packed-angle valves in suction and discharge lines of compressor, for gage taps at hot-gas bypass regulators, on each side of strainers.
- B. Install check valves in compressor discharge lines and in condenser liquid lines on multiple condenser systems.
- C. Install packed-angle valve in liquid line between receiver shutoff valve and thermostatic expansion valve for system charging.
- D. Install diaphragm packless or packed-angle valves on each side of strainers and dryers, in liquid and suction lines at evaporators, and elsewhere as indicated.
- E. Install a full-sized, three-valve bypass around each dryer.
- F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve.
 - 1. Install solenoid valves in horizontal lines with coil at top.
 - 2. Electrical wiring for solenoid valves is specified in Division 16 Sections. Coordinate electrical requirements and connections.
- G. Install thermostatic expansion valves as close as possible to evaporator.
 - 1. If refrigerant distributors are used, install them directly on expansion-valve outlet.
 - 2. Install valve so diaphragm case is warmer than bulb.
 - 3. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 4. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

- H. Install pressure regulating and pressure relief valves as required by ASHRAE 15. Pipe pressure relief valve discharge to outside.

3.3 SPECIALTY APPLICATIONS

- A. Install liquid indicators in liquid line leaving condenser, in liquid line leaving receiver, and on leaving side of liquid solenoid valves.
- B. Install strainers immediately upstream from each automatic valve, including expansion valves, solenoid valves, hot-gas bypass valves, and compressor suction valves.
- C. Install strainers in main liquid line where multiple expansion valves with integral strainers are used.
- D. Install strainers in suction line of steel pipe.
- E. Install moisture-liquid indicators in liquid lines between filter-dryers and thermostatic expansion valves and in liquid line to receiver.
- F. Install pressure relief valves on ASME receivers; pipe discharge to outdoors.
- G. Install replaceable-core filter-dryers in vertical liquid line adjacent to receivers and before each solenoid valve.
- H. Install permanent filter-dryers in low-temperature systems, in systems using hermetic compressors, and before each solenoid valve.
- I. Install solenoid valves in liquid line of systems operating with single pump-out or pump-down compressor control, in liquid line of single or multiple evaporator systems, and in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into suction line when system shuts down.
- J. Install receivers, sized to accommodate pump-down charge, on systems 5 tons (17.5 kW) and larger and on systems with long piping runs.
- K. Install flexible connectors at or near compressors.

3.4 PIPING INSTALLATION

- A. Install refrigerant piping according to ASHRAE 15.
- B. Basic piping installation requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."
- C. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- D. Arrange piping to allow inspection and service of compressor and other equipment. Install valves and specialties in accessible locations to allow for service and inspection.

- E. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- F. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.
- G. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- H. Install bypass around moisture-liquid indicators in lines larger than NPS 2 (DN 50).
- I. Install unions to allow removal of solenoid valves, pressure-regulating valves, and expansion valves and at connections to compressors and evaporators.
- J. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.
- K. Hanger, support, and anchor products are specified in Division 15 Section "Hangers and Supports."
- L. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6.0 m) long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6.0 m) or longer.
 - 3. Pipe rollers for multiple horizontal runs 20 feet (6.0 m) or longer, supported by a trapeze.
 - 4. Spring hangers to support vertical runs.
- M. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
 - 2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
 - 3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 1/4 inch (6.4 mm).
 - 4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
 - 5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
 - 6. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).

- N. Support vertical runs at each floor.

3.5 PIPE JOINT CONSTRUCTION

- A. Braze joints according to Division 15 Section "Basic Mechanical Materials and Methods."
- B. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide) during brazing to prevent scale formation.

3.6 FIELD QUALITY CONTROL

- A. Test and inspect refrigerant piping according to ASME B31.5, Chapter VI.
 - 1. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure.
 - 2. Test high- and low-pressure side piping of each system at not less than the lower of the design pressure or the setting of pressure relief device protecting high and low side of system.
 - a. System shall maintain test pressure at the manifold gage throughout duration of test.
 - b. Test joints and fittings by brushing a small amount of soap and glycerin solution over joint.
 - c. Fill system with nitrogen to raise a test pressure of 150 psig (1035 kPa) or higher as required by authorities having jurisdiction.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of the conditioned air controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Check compressor oil level above center of sight glass.
 - 2. Open compressor suction and discharge valves.
 - 3. Open refrigerant valves, except bypass valves that are used for other purposes.
 - 4. Check compressor-motor alignment, and lubricate motors and bearings.

3.8 CLEANING

- A. Replace core of filter-dryer after system has been adjusted and design flow rates and pressures are established.

3.9 SYSTEM CHARGING

- A. Charge system using the following procedures:
 1. Install core in filter-dryer after leak test but before evacuation.
 2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
 4. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

END OF SECTION

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SECTION 15185

HYDRONIC 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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.
- D. The requirements of Section 15071, "Mechanical Vibration and Seismic Control."

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Close-coupled, in-line centrifugal pumps.

1.3 SUBMITTALS

- A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
- B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
- B. Store pumps in dry location.
- C. Retain protective covers for flanges and protective coatings during storage.
- D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
- E. Comply with pump manufacturer's written rigging instructions.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Close-coupled, in-line centrifugal pumps
 - a. Armstrong Pumps Inc.
 - b. Bell & Gossett; Div. of ITT Industries.
 - c. Grundfos Pumps Corporation.
 - d. PACO Pumps.
 - e. Taco, Inc.
 - f. Weinman; Div. of Crane Pumps & Systems.

2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically. Rate pump for 125-psig maximum working pressure and a continuous water temperature of 250 deg F.
- B. Pump Construction:
 - 1. Casing: Cast iron, drilled and tapped for gauge ports at both suction and discharge flanges, with flanged connections.
 - 2. Impeller: ASTM B 584-836, red brass; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw
 - 3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
 - 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT bellows and gasket. Include water slinger on shaft between motor and seal.
- C. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated, and rigidly mounted to pump casing. Comply with requirements in Division 15050 Section "Motors for HVAC Equipment".

PART 3 - EXECUTION

3.4 EXAMINATION

- A. Examine equipment anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.5 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so that the pumps do not support the weight of the piping and the weight of the pumps is not supported by the piping.
- D. Install continuous-thread hanger rods and spring hangers with vertical-limit stop of sufficient size to support pump weight. Fabricate brackets or supports as required. Hanger and support materials are specified in Division 15 Section "Hangers and Supports."
- E. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and spring hangers

with vertical-limit stop of sufficient size to support pump weight. Hanger and support materials are specified in Division 15, Section 15060 "Hangers and Supports."

3.6 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install check valve and throttling valve on discharge side of pumps.
- F. Install Y-type strainer and shutoff valve on suction side of pumps.
- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- H. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.
- I. Install electrical connections for power, controls, and devices.
- J. Ground equipment according to Division 16 Section "Grounding and Bonding."
- K. Connect wiring according to Division 16 Section "Conductors and Cables."

END OF SECTION

SECTION 15194

FUEL GAS PIPING

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes fuel gas piping, specialties, and accessories within the building.
- B. Related Sections include the following:
 - 1. Division 2 Section "Natural Gas Distribution" for natural gas service piping, specialties, and accessories outside the building.
 - 2. Division 15 Section "Meters and Gages" for pressure gages.
 - 3. Division 15 Section 15071, "Mechanical Vibration & Seismic Control."

1.3 PROJECT CONDITIONS

- A. Gas System Pressures: Two pressure ranges. Primary pressure is more than 0.5 psig (3.45 kPa) but not more than 2.0 psig (13.8 kPa), and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.
- B. Design values of fuel gas supplied for these systems are as follows:
 - 1. Nominal Heating Value: 1053 Btu/cu. ft. (39.3 MJ/cu. m).
 - 2. Nominal Specific Gravity: 0.62

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Corrugated, stainless steel tubing systems. Include associated components.

2. Specialty valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 3. Pressure regulators. Include pressure rating, capacity, and settings of selected models.
- B. Shop Drawings: For fuel gas piping. Include plans and attachments to other Work. Show different pressure zones and indicate pressure for each zone.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- D. Maintenance Data: For natural gas specialties and accessories to include in maintenance manuals specified in Division 1.
- 1.5 QUALITY ASSURANCE
- A. ANSI Standard: Comply with ANSI Z223.1, "National Fuel Gas Code."
- B. FM Standard: Provide components listed in FM's "Fire Protection Approval Guide" if specified to be FM approved.
- C. IAS Standard: Provide components listed in IAS's "Directory of A. G. A. and C. G. A Certified Appliances and Accessories" if specified to be IAS listed.
- D. UL Standard: Provide components listed in UL's "Gas and Oil Equipment Directory" if specified to be UL listed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Corrugated, Stainless-Steel Tubing Systems:
 - a. Titeflex Corp.
 - b. Tru-Flex Metal Hose Corp.
 2. Appliance Connector Valves:
 - a. American Valve.
 - b. Brass Craft Manufacturing Co.
 - c. Conbraco Industries, Inc.; Apollo Div.
 - d. Jomar International, Ltd.
 - e. Mueller Co.; Mueller Gas Products Div.
 - f. Watts Industries, Inc.; Water Products Div.
 3. Gas Valves, NPS 2 (DN 50) and Smaller:

- a. Crane Valves.
- b. Flow Control Equipment, Inc.
- c. Grinnell Corp.
- d. Honeywell, Inc.
- e. Jomar International, Ltd.
- f. Kitz Corp. of America.
- g. Milwaukee Valve Co., Inc.
- h. Mueller Co.; Mueller Gas Products Div.
- i. Nibco, Inc.
- j. Watts Industries, Inc.; Water Products Div.

4. Plug Valves, NPS 2-1/2 (DN 65) and Larger:

- a. Flow Control Equipment, Inc.
- b. Nordstrom Valves, Inc.
- c. Walworth Co.

5. Line Pressure Regulators:

- a. Eclipse Combustion, Inc.
- b. Maxitrol Co.
- c. National Meter.

6. Appliance Pressure Regulators:

- a. Maxitrol Co.
- b. SCP, Inc.

2.2 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 CORRUGATED, STAINLESS-STEEL TUBING SYSTEMS

- A. Description: Comply with AGA LC 1 and include the following:

1. Tubing: Corrugated stainless steel with plastic jacket or coating.
2. Fittings: Copper alloy with ends made to fit corrugated tubing. Include ends with threads according to ASME B1.20.1 if connection to threaded pipe or fittings is required.
3. Striker Plates: Steel, designed to protect tubing from penetrations.
4. Manifolds: Malleable iron or steel with protective coating. Include threaded connections according to ASME B1.20.1 for pipe inlet and corrugated tubing outlets.

2.4 PIPES, TUBES, FITTINGS, AND JOINING MATERIALS

- A. Steel Pipe: ASTM A 53; Type E or S; Grade B; Schedule 40; black.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threaded ends according to ASME B1.20.1.
2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends according to ASME B1.20.1.
3. Cast-Iron Flanges and Flanged Fittings: ASME B16.1, Class 125.
4. Steel Welding Fittings: ASME B16.9, wrought steel or ASME B16.11, forged steel.
5. Steel Threaded Fittings: ASME B16.11, forged steel with threaded ends according to ASME B1.20.1.
6. Joint Compound and Tape: Suitable for natural gas.
7. Steel Flanges and Flanged Fittings: ASME B16.5.
8. Gasket Material: Thickness, material, and type suitable for natural gas.

2.5 PIPING SPECIALTIES

- A. Flexible Connectors: ANSI Z21.24, copper alloy.

2.6 SPECIALTY VALVES

- A. Valves, NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
- B. Valves, NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel flanges.
- C. Appliance Connector Valves: ANSI Z21.15 and IAS listed.
- D. Gas Stops: Bronze body with AGA stamp, plug type with bronze plug and flat or square head, ball type with chrome-plated brass ball and lever handle, or butterfly valve with stainless-steel disc and fluorocarbon elastomer seal and lever handle; 2-psig (13.8-kPa) minimum pressure rating.
- E. Gas Valves, NPS 2 (DN 50) and Smaller: ASME B16.33 and IAS-listed bronze body and 125-psig (860-kPa) pressure rating.
- F. Plug Valves, NPS 2-1/2 (DN 65) and Larger: ASME B16.38 and MSS SP-78 cast-iron, lubricated plug valves, with 125-psig (860-kPa) pressure rating.
- G. General-Duty Valves, NPS 2-1/2 (DN 65) and Larger: ASME B16.38, cast-iron body, suitable for fuel gas service, with "WOG" indicated on valve body, and 125 psig (860 kPa) pressure rating.
 1. Gate Valves: MSS SP-70, OS&Y type with solid wedge.
 2. Butterfly Valves: MSS SP-67, lug type with lever handle.

2.7 PRESSURE REGULATORS

- A. Description: Single stage and suitable for fuel gas service. Include steel jacket and corrosion-resistant components, elevation compensator, and atmospheric vent.
 - 1. NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - 2. NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
 - 3. Line Pressure Regulators: ANSI Z21.80 with 2-psig- (13.8-kPa-) maximum inlet pressure rating.
- B. Pressure Regulator Vents: Factory- or field-installed, corrosion-resistant screen in opening if not connected to vent piping.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Comply with ANSI Z223.1, "Prevention of Accidental Ignition" Paragraph.

3.2 PIPING APPLICATIONS

- A. Flanges, unions, transition, and special fittings with pressure ratings same as or higher than system pressure rating may be used in applications below, unless otherwise indicated.
- B. Fuel Gas Piping, 0.5 psig (3.45 kPa) or Less: Use the following:
 - 1. NPS 1/2 (DN 15) and Smaller: NPS 3/4 (DN 20) steel pipe, malleable-iron threaded fittings, and threaded joints.
 - 2. NPS 1/2 (DN 15) and Smaller: Corrugated, stainless steel tubing system and threaded joints.
 - 3. NPS 3/4 and NPS 1 (DN 20 and DN 25): Steel pipe, malleable-iron threaded fittings, and threaded joints.
 - 4. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): Steel pipe, malleable-iron threaded fittings, and threaded joints.
 - 5. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Steel pipe, malleable-iron threaded fittings, and threaded joints.
- C. Fuel Gas Piping, 0.5 to 2 psig (3.45 to 13.8 kPa): Use the following:
 - 1. NPS 1/2 (DN 15) and Smaller: NPS 3/4 (DN 20) steel pipe, steel welding fittings, and welded joints.
 - 2. NPS 3/4 and NPS 1 (DN 20 and DN 25): Steel pipe, steel welded fittings, and welded joints.
 - 3. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): Steel pipe, steel welding fittings, and welded joints.

4. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Steel pipe, steel welding fittings, and welded joints.

3.3 VALVE APPLICATIONS

- A. Appliance Shutoff Valves for Pressure 0.5 psig (3.45 kPa) or Less: Appliance connector valve or gas stop.
- B. Appliance Shutoff Valves for Pressure 0.5 to 2 psig (3.45 to 13.8 kPa): Gas stop or gas valve.
- C. Appliance Shutoff Valves for Pressure 2 to 5 psig (13.8 to 34.5 kPa): Gas valve.
- D. Piping Line Valves, NPS 2 (DN 50) and Smaller: Gas valve.
- E. Piping Line Valves, NPS 2-1/2 (DN 65) and Larger: Plug valve or general-duty valve.
- F. Valves at Service Meter, NPS 2 (DN 50) and Smaller: Gas valve.
- G. Valves at Service Meter, NPS 2-1/2 (DN 65) and Larger: Plug valve.

3.4 PIPING INSTALLATION

- A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.
- B. Concealed Locations: Except as specified below, install concealed gas piping in airtight conduit constructed of Schedule 40, seamless, black steel pipe with welded joints. Vent conduit to outside and terminate with screened vent cap.
 1. Above-Ceiling Locations: Gas piping may be installed in accessible spaces, subject to approval of authorities having jurisdiction, whether or not such spaces are used as plenums. Do not locate valves above ceilings.
 2. In Floors: Gas piping with welded joints and protective wrapping specified in "Protective Coating" Article in Part 2 may be installed in floors, subject to approval of authorities having jurisdiction. Surround piping cast in concrete slabs with minimum of 1-1/2 inches (40 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
 3. In Floor Channels: Gas piping may be installed in floor channels, subject to approval of authorities having jurisdiction. Channels must have cover and be open to space above cover for ventilation.
 4. In Partitions: Do not install concealed piping in solid partitions. Protect tubing from physical damage when installed inside partitions or hollow walls.
 - a. Exception: Tubing passing through partitions or walls.

5. In Walls: Gas piping with welded joints and protective wrapping specified in "Protective Coating" Article in Part 2, may be installed in masonry walls, subject to approval of authorities having jurisdiction.
6. Prohibited Locations: Do not install gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - a. Exception: Accessible above-ceiling space specified above.
- C. Drips and Sediment Traps: Install drips at points where condensate may collect. Include outlets of service meters. Locate where readily accessible for cleaning and emptying. Do not install where condensate would be subject to freezing.
 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use minimum-length nipple of 3 pipe diameters, but not less than 3 inches (75 mm) long, and same size as connected pipe. Install with space between bottom of drip and floor for removal of plug or cap.
- D. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels, unless they are indicated exposed to view.
- E. Install fuel gas piping at uniform grade of 0.1 percent slope upward toward risers.
- F. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- G. Connect branch piping from top or side of horizontal piping.
- H. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.
- I. Install corrugated, stainless-steel tubing system according to manufacturer's written instructions. Include striker plates to protect tubing from puncture where tubing is restrained and cannot move.
- J. Install strainer on inlet of each line pressure regulator and automatic and electrically operated valve.
- K. Install pressure gage upstream and downstream from each line pressure regulator.
- L. Install flanges on valves, specialties, and equipment having NPS 2-1/2 (DN 65) and larger connections.
- M. Install vent piping for gas pressure regulators and gas trains, extend outside building, and vent to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end.

3.5 JOINT CONSTRUCTION

- A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.
- B. Use materials suitable for fuel gas.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Refer to Division 15 Section "Hangers and Supports" for pipe hanger and support devices. Install seismic bracing on natural gas piping per Section 15071, "Mechanical Vibration & Seismic Control."
- B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
 - 2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
 - 3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
 - 4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
- C. Install hangers for horizontal corrugated, stainless-steel tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): Maximum span, 48 inches (1219 mm); minimum rod size, 3/8 inch (10 mm).
 - 2. NPS 3/4 and NPS 1 (DN 20 and DN 25): Maximum span, 72 inches (1829 mm); minimum rod size, 3/8 inch (10 mm).
 - 3. Option: Support tubing from structure according to manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of fuel gas piping, fittings, and specialties.
- B. Install piping adjacent to appliances to allow service and maintenance.
- C. Connect piping to appliances using gas with shutoff valves and unions. Install valve upstream from and within 72 inches (1800 mm) of each appliance. Install union downstream from valve.
- D. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance using gas.

3.8 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each service meter, pressure regulator, and specialty valve.
 - 1. Text: In addition to name of identified unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
 - 2. Refer to Division 15 Section "Basic Mechanical Materials and Methods" ["Mechanical Identification" for nameplates and signs.

3.9 FIELD QUALITY CONTROL

- A. Inspect, test, and purge piping according to ANSI Z223.1, Part 4 "Inspection, Testing, and Purging," and requirements of authorities having jurisdiction.
- B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.
- C. Report test results promptly and in writing to the Architect and authorities having jurisdiction.
- D. Verify capacities and pressure ratings of service meters, pressure regulators, valves, and specialties.
- E. Verify correct pressure settings for pressure regulators.
- F. Verify that specified piping tests are complete.

3.10 ADJUSTING

- A. Adjust controls and safety devices. Replace damaged and malfunctioning controls and safety devices.

END OF SECTION

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SECTION 15410

PLUMBING FIXTURES

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by this Section.

1.2 SUMMARY

- A. This Section includes plumbing fixtures and related components.
- B. Related Sections include the following:
 - 1. Section 15430, "Plumbing Specialties" for water distribution piping specialties.

1.3 DEFINITIONS

- A. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
- B. Fitting: Device that controls flow of water into or out of plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, showerheads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.
- C. ADA: Americans with Disabilities Act.

1.4 SUBMITTALS

- A. Pre-Construction Submittals: Submit the following items prior to commencing with the installations.
 - 1. Product Data: Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports and indicate materials and finishes, dimensions, construction details, and flow-control rates for each type of fixture indicated.
 - 2. Shop Drawings: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

- B. Post Construction Submittals: Submit the following items upon completion of system installations.
 - 1. Maintenance Data: For plumbing fixtures to include in maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
 - 1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.
- 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. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; about plumbing fixtures for people with disabilities.
- D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
- F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
- G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
 - 1. Plastic Shower Enclosures: ANSI Z124.2.
 - 2. Stainless-Steel Fixtures Other Than Service Sinks: ASME A112.19.3M.
 - 3. Vitreous-China Fixtures: ASME A112.19.2M.
- H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
 - 1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
 - 2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
 - 3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
 - 4. Faucet Hose: ASTM D 3901.
 - 5. Faucets: ASME A112.18.1M.
 - 6. Hose-Connection Vacuum Breakers: ASSE 1011.
 - 7. Hose-Coupling Threads: ASME B1.20.7.
 - 8. Integral, Atmospheric Vacuum Breakers: ASSE 1001.

9. NSF Materials: NSF 61.
10. Pipe Threads: ASME B1.20.1.
11. Supply and Drain Fittings: ASME A112.18.1M.

I. Comply with the following applicable standards and other requirements specified for shower faucets:

1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.
3. Faucets: ASME A112.18.1M.
4. Hand-Held Showers: ASSE 1014.
5. High-Temperature-Limit Controls for Thermal-Shock-Preventing Devices: ASTM F 445.
6. Hose-Coupling Threads: ASME B1.20.7.
7. Manual-Control Antiscald Faucets: ASTM F 444.
8. Pipe Threads: ASME B1.20.1.
9. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
10. Thermostatic-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.

J. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

1. Atmospheric Vacuum Breakers: ASSE 1001.
2. Brass and Copper Supplies: ASME A112.18.1M.
3. Tubular Brass Drainage Fittings and Piping: ASME A112.18.1M.

K. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Floor Drains: ASME A112.21.1M.
2. Grab Bars: ASTM F 446.
3. Hose-Coupling Threads: ASME B1.20.7.
4. Off-Floor Fixture Supports: ASME A112.6.1M.
5. Pipe Threads: ASME B1.20.1.
6. Plastic Shower Receptors: ANSI Z124.2.
7. Plastic Toilet Seats: ANSI Z124.5.

1.6 COORDINATION

- A. Coordinate roughing-in and final plumbing fixture locations, and verify that fixtures can be installed to comply with original design and referenced standards.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed below.
- B. Commercial Cast Brass Faucets:
 - 1. Chicago Faucet Co.
 - 2. Zurn Industries, Inc.
- C. Shower Heads and Trim:
 - 1. Symmons Industries, Inc.
 - 2. Powers, Watts Industries
- D. Flush Valves:
 - 1. Sloan Valve Co.
 - 2. Toto U.S.A.
- E. Toilet Seats:
 - 1. Church Seat Co.
- F. Fixture Carriers and Supports:
 - 1. Zurn Industries, Inc.
 - 2. J.R. Smith Mfg. Co.
 - 3. Iosam Co.
- G. Supply Stops:
 - 1. Chicago Faucet Co.
 - 2. McGuire Mfg. Co.
- H. Lavatory Faucets:
 - 1. Chicago Faucets
 - 2. Zurn Industries, Inc.
 - 3. Toto U.S.A.
- I. Vitreous China Fixtures:
 - 1. Kohler Co.
 - 2. American Standard
 - 3. Zurn Industries, Inc.
- J. Pre-fabricated Plastic Shower Cabinets and Bathtubs:
 - 1. Acryline USA, Inc.
 - 2. Crane-Fiat
- K. Stainless Steel Sinks:
 - 1. Just Mfg. Co.
 - 2. Elkay Mfg. Co.
 - 3. Kindred.

L. Molded Stone and Plastic Basins:

1. Fiat Products.
2. Swan.

M. Waterless Urinals:

1. Uridan
2. Falcon
3. Waterless
4. Eljer

2.2 FIXTURES, GENERAL

- A. General fixture, faucet and related item requirements are listed below. Refer to the "Plumbing Fixture Schedule" on the Drawings for the basis of design for each item.
- B. Accessibility: Fixtures and items that are required to be accessible are tagged as such in the Plumbing Fixture Schedule on the Drawings.

2.3 FAUCETS

- A. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.
 1. Maximum Flow Rate, (unless otherwise indicated):
 - a. Sinks, Bathtubs, Showers: 2.5 gpm.
 - b. Lavatories: 0.5 gpm
 2. Body Material: Cast brass
 3. Finish: Polished chrome plate
 4. Vacuum Breaker: Required for service sinks, basins, science and laboratory sinks.
 - a. Required at any sink faucet that has exposed hose thread end(s).

2.4 FLUSHOMETERS

- A. General: Cast-brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, and copper or brass tubing, and polished chrome-plated finish on exposed parts.
 1. Internal Design: Diaphragm operation.
 2. Style: Exposed, unless noted otherwise.
 3. Inlet Size: NPS 1.
 - a. Urinals; NO WATER
 4. Trip Mechanism: Oscillating, lever-handle, self-charging battery, and electric-sensor.
 5. Consumption:
 - a. Water Closets: 1.6 gal. /flush.
 - b. Urinals: NO WATER
 6. Tailpiece Size: Diameter scheduled, length to top of bowl.

2.5 TOILET SEATS

- A. General: Solid plastic, open front, without cover, self-sustaining check hinges.
 - 1. Color: White.
 - 2. Size: Elongated, unless otherwise noted.

2.6 PROTECTIVE SHIELDING GUARDS

- A. General: Manufactured insulation and plastic covering for water supply, trap and drain piping and complying with ADA requirements.

2.7 FIXTURE SUPPORTS

- A. Water-Closet Support: Water-closet combination carrier designed for accessible and standard mounting heights, (see schedule). Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.
- B. Lavatory and Sink Supports: Lavatory carrier with concealed arms and tie rod. Include steel uprights with feet.

2.8 SUPPLY STOPS

- A. General: Cast brass or copper, chrome plated angle style with chrome plated escutcheon and loose key operator.
 - 1. Lavatory Supplies: NPS 3/8.
 - 2. Sink and Tank Style Water Closet Supplies: NPS 1/2.

2.9 WATER CLOSETS

- A. General: Commercial, vitreous-china fixture, siphon jet design, 1.6 gal. /flush.
 - 1. Mounting: Wall hung.
 - 2. Outlet: Back.
 - 3. Flush style: Flush valve.
 - a. No-Touch, electric, self-generating/manual (See 2.4A above).
 - 4. Color: White.

2.10 URINALS

- A. General: Wall hung, back-outlet, vitreous-china/fiberglass fixture designed for waterless operation.
 - 1. Color: White.
 - 2. Flush style: Flush valve.
 - a. No water is used.

2.11 LAVATORIES

- A. General: Wall hung vitreous-china fixture.
 - 1. Color: White.

2.12 PRE-FABRICATED SHOWER CABINETS

- A. General: Acrylic plastic shower enclosure with slip-resistant bathing surface complying with ASTM F 462 and shower rod with curtain.
 - 1. Cabinet Configuration: One-piece surround.
 - 2. Color: White.
 - 3. Drain: Grid, NPS 2.
 - 4. Accessibility Options: Include grab bars and bench meeting applicable accessibility requirements for units designated as accessible in the Plumbing Fixture Schedule on the Drawings.
 - a. Threshold: 3/4-inch maximum lip allowed at front entrance to the cabinet.

2.13 GENERAL USE SINKS

- A. General: Commercial, counter mount, self-rimming, sound deadening fixture.
 - 1. Material: 18 gauge, type 316 stainless steel **ONLY** in areas where exposed to salt water. Sink in Kitchenette can be 18 gauge, type 304 stainless steel.

2.14 SERVICE FIXTURES

- A. Mop Service Basins: Flush-to-wall, floor-mounting precast terrazzo basin with rim guards.
 - 1. Drain: NPS 3. grid.
 - 2. Accessories: Mop hanger, splashguards, faucet and hose attachment.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water soil and for waste piping systems and supports to verify actual locations and sizes of piping connections and that locations and types of supports match those indicated, before plumbing fixture installation. Use manufacturer's roughing-in data if roughing-in data are not indicated.
- B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FIXTURE INSTALLATION

- A. Assemble fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. For wall-hanging fixtures, install off-floor supports affixed to building substrate.
 - 1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 - 2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 - 3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
- C. Install back-outlet, wall hanging fixtures onto waste fitting seals and attach to supports.
- D. Install wall-hanging fixtures with tubular waste piping attached to supports.
- E. Install counter-mounting fixtures in and attached to casework.
- F. Install fixtures level and plumb according to manufacturers' written instructions and roughing-in drawings.
- G. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
 - 1. Exception: Use ball, gate, or globe valve if stops are not specified with fixture.
- H. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- I. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
- J. Install protective shielding guards on exposed under counter supply and waste piping at fixtures identified as accessible and at other locations scheduled.
- K. Install toilet seats on water closets.
- L. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- M. Install water supply, flow-control fittings with specified flow rates in fixture supplies at stop valves.
- N. Install faucet, flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- O. Install shower, flow-control fittings with specified maximum flow rates in shower arms.
- P. Install traps on fixture outlets.
 - 1. Exception: Omit trap on fixtures with integral traps.

2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

- Q. Install escutcheons at piping wall/ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for escutcheons.
- R. Set shower receptors, and service basins in leveling bed of cement grout. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for grout.
- S. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Refer to Division 7 Section "Joint Sealants" for sealant and installation requirements.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect water supplies from water distribution piping to fixtures.
- C. Connect drain piping from fixtures to drainage piping.
- D. Supply and Waste Connections to Plumbing Fixtures: Connect fixtures with water supplies, stops, risers, traps, and waste piping. Use size fittings required to match fixtures. Connect to plumbing piping.
- E. Supply and Waste Connections to Fixtures and Equipment Specified in Other Sections: Connect fixtures and equipment with water supplies, stops, risers, traps, and waste piping specified. Use size fittings required to match fixtures and equipment. Connect to plumbing piping.
- F. Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Verify that installed fixtures are categories and types specified for locations where installed.
- B. Check that fixtures are complete with trim, faucets, fittings, and other specified components.
- C. Inspect installed fixtures for damage. Replace damaged fixtures and components.
- D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.5 ADJUSTING

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Adjust water pressure at faucets, shower valves, and flushometer valves to produce proper flow and stream.
- C. Replace washers and seals of leaking and dripping faucets and stops.

3.6 CLEANING

- A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
 - 1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
 - 2. Remove sediment and debris from drains.

3.7 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 15430

PLUMBING SPECIALTIES

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by this Section.

1.2 SUMMARY

- A. This Section includes the following plumbing specialties:
 - 1. Backflow preventers.
 - 2. Balancing valves.
 - 3. Strainers.
 - 4. Exterior wall hydrants.
 - 5. Drain valves.
 - 6. Miscellaneous piping specialties.
 - 7. Cleanouts.
 - 8. Floor drains.
- B. Related Sections include the following:
 - 1. Section 15122, "Meters and Gages" for water meters, (other than at municipal entrances), thermometers, and pressure gages.

1.3 DEFINITIONS

- A. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing piping systems with following minimum working-pressure ratings, unless otherwise indicated:
 - 1. Water Supply Systems, Above Ground: 125 psig.

2. Water Supply Systems, Below Ground: 150 psig.
3. DWV, (Gravity) Systems: 10 foot of head of water.

1.5 SUBMITTALS

- A. General: See Division 1 for general submittal and product substitution requirements.
- B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.
 1. Product Data, including wiring diagrams for electrically and battery powered items.
 - a. Backflow preventers and water regulators.
 - b. Balancing valves, water filters, and strainers.
 - c. Water hammer arresters, air vents, and trap seal primer valves and systems.
 - d. Drain valves, hose bibbs, and wall hydrants.
 - e. Refrigerator wall boxes.
 - f. Cleanouts, floor drains, open receptors, and roof drains.
 - g. Emergency equipment.
- C. Post Construction Submittals: Submit the following items upon completion of system installations.
 1. Maintenance Data: For plumbing specialties to include in maintenance manuals. Include the following:
 - a. Backflow preventers and water regulators.
 - b. Trap seal primer valves and systems.
 - c. Wall hydrants.

1.6 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of plumbing specialties and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- B. Plumbing specialties shall bear label, stamp, or other markings of specified testing agency.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for piping materials and installation.
- E. NSF Compliance:
 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components. Include marking "NSF-DWV" on plastic drain, waste, and vent piping.

2. Comply with NSF 61, "Drinking Water System Components--Health Effects, Sections 1 through 9," for potable domestic water plumbing specialties.

1.7 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. Operating Key Handles: Equal to 100 percent of amount installed for each key-operated hose bibb and hydrant installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed below.
- B. Backflow Preventers:
 1. Ames Co., Inc.
 2. CMB Industries, Inc.; Febco Backflow Preventers.
 3. Conbraco Industries, Inc.
 4. Watts Industries, Inc.; Water Products Div.
 5. Zurn Industries, Inc.; Wilkins Div.
- C. Water Meters: Water meter to be provided by the local water authority, Portland Water District. Plumbing Contractor to install.
- D. Calibrated Circulated Hot Water Balancing Valves:
 1. ITT Industries; Bell & Gossett Div.
 2. Taco, Inc.
 3. Watts Industries, Inc.; Water Products Div.
- E. Exterior Wall Hydrants:
 1. Smith, Jay R. Mfg. Co.
 2. Tyler Pipe; Wade Div.
 3. Watts Industries, Inc.; Drainage Products Div.
 4. Zurn Industries, Inc.
- F. Trap Seal Primer Valves:
 1. Precision Plumbing Products, Inc.
 2. Smith, Jay R. Mfg. Co.
 3. Tyler Pipe; Wade Div.
 4. Watts Industries, Inc.

5. Zurn Industries, Inc.

G. Water Hammer Arresters:

1. Josam Co.
2. Precision Plumbing Products, Inc.
3. Sioux Chief Manufacturing Co., Inc.
4. Watts Industries, Inc.
5. Smith, Jay R. Mfg. Co.
6. Zurn Industries, Inc.; Wilkins Div.

H. Hose Bibbs:

1. Chicago Faucet Co.
2. T & S Brass and Bronze Works, Inc.
3. Royal Brass Mfg. Co.

I. Cleanouts; Floor, and Roof Drains:

1. Watts Industries, Inc.
2. Smith, Jay R. Mfg. Co.
3. Zurn Industries, Inc.; Wilkins Div.
4. Josam Co.
5. Tyler Pipe; Wade Div.

2.2 BACKFLOW PREVENTERS

A. General: ASSE standard, backflow preventers.

1. NPS 2 and Smaller: Bronze body with threaded ends.
2. NPS 2-1/2 and Larger: Bronze, cast-iron, steel, or stainless steel body with flanged ends.
 - a. Interior Lining: AWWA C550 or FDA-approved, epoxy coating for backflow preventers having cast-iron or steel body.
3. Interior Components: Corrosion-resistant materials.
4. Exterior Finish: Polished chrome plate if used in chrome-plated piping system.
5. Strainer: Provide strainer on inlet. Include draw off valve with cap and chain.
 - a. Exception: Where backflow preventers are located immediately downstream of a water meter and strainer, a strainer is not required at the backflow preventer, unless specifically required by the applicable water authority.

B. Reduced-Pressure-Principle Backflow Preventers: ASSE 1013, suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet; test cocks; and pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves.

1. Pressure Loss: 12-psig maximum, through middle 1/3 of flow range.

2.3 WATER METERS

- A. General: Install meter as provided by the local water supplier.

2.4 BALANCING VALVES

- A. Calibrated Balancing Valves: Adjustable, with two readout ports and memory setting indicator. Include manufacturer's standard hoses, fittings, valves, differential pressure meter, and carrying case.
 - 1. NPS 2 and Smaller: Bronze body with brass ball, adjustment knob, calibrated nameplate, and threaded or solder-joint ends.
 - 2. NPS 2-1/2 and Larger: Cast-iron, Y-pattern body with bronze disc and flanged or grooved ends.

2.5 STRAINERS

- A. Strainers: Y-pattern, unless otherwise indicated, and full size of connecting piping. Include ASTM A 666, Type 304, stainless-steel screens with 3/64-inch round perforations, unless otherwise indicated.
 - 1. Pressure Rating: 125-psig minimum steam working pressure, unless otherwise indicated.
 - 2. NPS 2 and Smaller: Bronze body, with female threaded ends.
 - 3. NPS 2-1/2 and Larger: Cast-iron body, with interior AWWA C550 or FDA-approved, epoxy coating and flanged ends.
 - 4. Y-Pattern Strainers: Screwed screen retainer with centered blowdown.
 - a. Drain: Factory- or field-installed, hose-end drain valve.
 - 5. T-Pattern Strainers: Malleable-iron or ductile-iron body with grooved ends; access end cap with drain plug and access coupling with rubber gasket.

2.6 WALL HYDRANTS

- A. General: ASME A112.21.3M, key-operation hydrant with pressure rating of 125 psig.
 - 1. Inlet: NPS 3/4 or NPS 1 threaded or solder joint.
 - 2. Outlet: ASME B1.20.7, garden-hose threads.
 - 3. Operating Keys: One with each key-operation hydrant.
- B. Nonfreezing Concealed-Outlet Wall Hydrants: ASSE 1019, self-drainable with flush-mounting box with cover, integral non-removable hose-connection vacuum breaker, casing and operating rod to match wall thickness, concealed outlet, and wall clamp.
 - 1. Box and Cover Finish: Polished nickel bronze.
 - 2. Basis of Design: As scheduled on the Drawings.

2.7 TRAP SEAL PRIMER VALVES

- A. Supply-Type Trap Seal Primer Valves: ASSE 1018, water-supply-fed type, with the following characteristics:
 - 1. 125-psig minimum working pressure.
 - 2. Bronze body with atmospheric-vented drain chamber.
 - 3. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
 - 4. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
 - 5. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.8 DRAIN VALVES

- A. Hose-End Drain Valves: MSS SP-110, NPS 3/4 ball valve, rated for 400-psig minimum CWP. Include two-piece, copper-alloy body with standard port, chrome-plated brass ball, replaceable seats and seals, blowout-proof stem, and vinyl-covered steel handle.
 - 1. Inlet: Threaded or solder joint.
 - 2. Outlet: Short-threaded nipple with ASME B1.20.7, garden-hose threads and cap.
- B. Stop-and-Waste Drain Valves: MSS SP-110, ball valve, rated for 200-psig minimum CWP or MSS SP-80, Class 125, gate valve; ASTM B 62 bronze body, with NPS 1/8 side drain outlet and cap.

2.9 WATER HAMMER ARRESTERS

- A. General: ASSE 1010 or PDI-WH 201, piston type with pressurized metal-tube cushioning chamber. Sizes indicated are based on ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.10 HOSE BIBBS

- A. General: Bronze body with replaceable seat disc complying with ASME A112.18.1M for compression-type faucets. Include NPS 3/4 threaded or solder-joint inlet, of design suitable for pressure of at least 125 psig; integral non-removable, drainable hose-connection vacuum breaker and garden-hose threads complying with ASME B1.20.7 on outlet.
 - 1. Finish for Equipment Rooms: Rough bronze, or chrome or nickel-plated.
 - 2. Finish for Finished Rooms: Chrome or nickel-plated.
 - 3. Operation: Operating key.
 - 4. Include operating key with each operating-key hose bibb.
 - 5. Include wall flange with each chrome- or nickel-plated hose bibb.
- B. Basis of Design: As scheduled on the Drawings.

2.11 MISCELLANEOUS PIPING SPECIALTIES

- A. Open End Drains, (or "Stand Drains"): Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, backwater valve, hub-and-spigot riser section; and increaser fitting, joined with ASTM C 564, rubber gaskets.
- B. Deep-Seal Traps: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap seal primer valve connection.
 - 1. NPS 2: 4-inch- minimum water seal.
 - 2. NPS 2-1/2 and Larger: 5-inch- minimum water seal.
- C. Fixed Air-Gap Fittings: Manufactured cast-iron or bronze drainage fitting with semi open top with threads or device to secure drainage inlet piping in top and bottom spigot or threaded outlet larger than top inlet. Include design complying with ASME A112.1.2 that will provide fixed air gap between installed inlet and outlet piping.
- D. Wall Accessible Cleanouts: Line type with lacquered cast iron body, gas and water tight tapered thread plug, and round stainless steel access cover secured with machine screw.
 - 1. Basis of Design: Zurn #Z-1441.
- E. Finished Floor Cleanouts: Lacquered cast iron body with anchor flange, reversible clamping collar, adjustable threaded top assembly, and round, gasketed cover.
 - 1. Cover to be scored in unfinished and service areas.
 - 2. Cover to be depressed to receive floor finish material in finished spaces.
 - 3. Basis of Design: Zurn #Z-1400.

2.12 FLOOR DRAINS

- A. General: ASME A112.21.2M; Provide trap primer inlet connections on drain bodies unless otherwise scheduled.
 - 1. Where drains do not require trap primers, install a threaded plug in the primer inlet port. Plug to be of a dielectrically compatible material.
 - 2. Basis of Design: As scheduled on the Drawings.
- B. Floor Drains:
 - 1. Body Material: Cast Iron.
 - 2. Seepage Flange and Clamping Device: Required for interior application.
 - 3. Anchor Flange: Required for exterior application.
 - 4. Exposed Surfaces and Interior Lining: As scheduled.
 - 5. Outlet Style: Hub and Spigot for slab-on-grade applications. No-hub for above grade applications.
 - 6. Sediment Bucket and Grate Variations: As scheduled.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 - 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.

- B. Water Meter Installation: Rough-in domestic water piping according to utility company's requirements. Install water meters according to AWWA M6 and utility's requirements.
 - 1. Install displacement-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
 - 2. Install turbine-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
 - 3. Install compound-type water meters with shutoff valves on water-meter inlet and outlet and on valved bypass around meter. Support meters, valves, and piping on brick or concrete piers.
 - 4. Install remote registration system according to standards of utility and of authorities having jurisdiction.

- C. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve.

- D. Install interior hose bibs 18-inches above finished floors.

- E. Install exterior wall hydrants 18-inches above finished grade.

- F. Install trap seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

- G. Drain Valve Application: Install hose end drain valves at the base of system risers.
 - 1. Acceptable Alternate: For ¾-inch supply risers that serve only one story above, stop-and-waste shut-off valves may be used in lieu of shut-off valves and separate drain valves.

- H. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 - 1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate at each change in direction of piping greater than 45 degrees.
 - 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 - 4. Locate at base of each vertical soil and waste stack.

- I. Install cleanout deck plates with top flush with finished floor, for floor cleanouts for piping below floors.
- J. Install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall, for cleanouts located in concealed piping.
- K. Install flashing flange and clamping device with each stack and cleanout passing through floors with waterproof membrane.
- L. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 - 1. Position floor drains for easy access and maintenance.
 - 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
 - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
 - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
 - 3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 - 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- M. Fasten wall-hanging plumbing specialties securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated.
- N. Fasten recessed-type plumbing specialties to reinforcement built into walls.
- O. Install wood-blocking reinforcement for wall mounting and recessed-type plumbing specialties.
- P. Install individual shutoff valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve is not indicated. Install shutoff valves in accessible locations.
- Q. Install air vents at piping high points. Include ball valve in inlet and drain piping from outlet to floor drain.
- R. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- S. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

3.3 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 15445

SEWAGE AND SUMP 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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following sewage and sump pumps and accessories for sanitary waste and storm drainage piping systems in buildings:
 - 1. Wet-pit-mounted, vertical sewage and sump pump systems.
 - 2. Oil retaining sump pump systems.
- B. Related Sections include the following:
 - 1. Division 15 Section "Meters and Gauges" for pressure gauges."
 - 2. Section 15140, "Plumbing Piping and Specialties" for system pipe, fittings and valves.

1.3 SUBMITTALS

- A. General: See Division 1 for general submittal and product substitution requirements.
- B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.
 - 1. Product Data: For each type and size of pump system specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.
 - 2. Shop Drawings: Diagram power, signal, basin, control panel and control wiring.
 - 3. Warranty data.
- C. Post Construction Submittals: Submit the following items upon completion of system installations.
 - 1. Operation and Maintenance Data: For each pump system to include in operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of pump systems 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.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with pump manufacturer's written rigging instructions for handling.

1.6 COORDINATION

- A. Coordinate size and location of pits and basins with concrete work. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
- B. Wet-pit-mounted, vertical sewage and sump pump systems:
 - 1. Armstrong Pumps Inc.
 - 2. Sterling Peerless; Sterling Fluid Systems Group.
 - 3. Weil Pump Company, Inc.
 - 4. Weinman Div.; Crane Pumps & Systems.
 - 5. Yeomans Chicago Corporation.
- C. Oil retaining sump pump systems:
 - 1. Stancor, Inc.

2.2 WET-PIT-MOUNTED, VERTICAL SEWAGE AND SUMP PUMP SYSTEMS

- A. Description: Packaged pump system which includes: Pump(s), basin, curb frame, cover, controls, wiring and piping systems.

- B. Pumps: Factory-assembled and -tested, single-stage, centrifugal, end-suction sewage pumps complying with UL 778. Vertical, separately coupled, suspended pumps complying with HI 1.1-1.2 and HI 1.3 for wet-pit-volute sewage pumps.
1. Casing: Cast iron, with open inlet and threaded connection for NPS 2 (DN 50) and smaller and flanged connection for NPS 2-1/2 (DN 65) and larger discharge piping.
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, open or semi-open, nonclog design for solids handling; overhung, single suction, and keyed and secured to shaft.
 3. Pump Shaft and Sleeve Bearings: Stainless-steel or steel shaft with bronze sleeve bearings. Include oil-lubricated, intermediate sleeve bearings at 48-inch (1200-mm) maximum intervals if basin depth is more than 48 inches (1200 mm), and grease-lubricated, ball-type thrust bearings.
 4. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
- C. Pump Discharge Piping: Manufacturer's standard galvanized-steel or bronze pipe.
- D. Motors: Single-speed; grease-lubricated ball bearings. Comply with requirements in Section 15050, "Basic Mechanical Materials and Methods."
1. Mounting: On vertical, cast-iron pedestal.
- E. Controls: NEMA 250, Type 4 enclosure, micro-pressure or mercury float switches; with mounting rod. Include automatic alternator to alternate operation of pump units on successive cycles and to operate multiple units if one pump cannot handle load.
1. Remote Mounting: Provide control panel for mounting on a wall or strut rack adjacent to the pump system.
 2. Float Guide: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
 3. High-Water Alarm: Cover-mounted, mercury-float-switch, alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 4. Control Settings: Dimensional location of control switches within the pump basin to be as identified on the Drawings and as recommended by the pump manufacturer. Settings to include;
 - a. Pump(s) off.
 - b. Primary pump on.
 - c. Secondary pump on, (for duplex application).
 - d. High water condition.
- F. Wiring: System to be pre-wired in as much as possible. Where panel mounting is remote to the system, adequate wiring shall be included. Unit shall be provided such that the project Electrical contractor's scope will not include interconnecting wiring.
- G. Basin: Factory fabricated sump with pipe connections, and separate cover.
1. Sump: Fabricate watertight, with sidewall openings for pipe connections.
 - a. Material: Fiberglass.
 - b. Reinforcement: Mounting plates for pumps, fittings, guide-rail supports, and accessories.
 - c. Anchor Flange or Curb Frame: Same material as or compatible with sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.

- d. Piping Connections: As indicated on the Drawings.
 2. Cover: Fabricate with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
 - a. Material: Cast iron or steel with bituminous coating.
 - b. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.
 3. Cover Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.
 4. Basin Depth and Cover Diameter: As scheduled and indicated on the Drawings.
- H. Basis of Design: As scheduled on the Drawings.

2.3 OIL RETAINING SUMP PUMP SYSTEMS

- A. Description: Pump and control system which includes an oil sensing probe to identify the presence of oil, hydraulic fluid or other similar substances.
- B. Pump: Factory-assembled and -tested, single-stage, centrifugal, end-suction, automatic-operation, submersible effluent pump unit.
 1. Pump Body and Impeller: Corrosion-resistant materials.
 2. Pump Seals: Mechanical type.
 3. Motor: Hermetically sealed, capacitor-start type, with built-in overload protection. Comply with requirements of Section 15050, Basic Mechanical Materials and Methods."
- C. Control: UL 508, NEMA 4X gasketed enclosure, local audible alarm as well as contacts for building automation system interface. Panel shall include 16 foot long cables for connection to the pump, and an 8-foot power cord. Pump control to include a self cleaning, corrosion resistant sensor probe. Alarm conditions shall be as follows;
 1. Presence of oil in the sump.
 2. High liquid in the sump.
 3. High amps or locked rotor.
- D. Basis of Design: As scheduled on the Drawings.

2.4 BUILDING AUTOMATION SYSTEM INTERFACE

- A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:
 1. On-off status of each pump.
 2. Alarm status.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for plumbing piping to verify actual locations of piping connections before pump system installation.

3.2 INSTALLATION

- A. Excavating, trenching, and backfilling are specified in Division 2 Section "Earthwork."
- B. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.
- C. Suspend wet-pit-mounted, vertical pumps from basin covers. Make direct connections to drainage piping.
- D. Set submersible pumps on basin floors. Make direct connections to drainage piping.
 - 1. Anchor guide-rail supports to basin bottoms and sidewalls or covers. Install pumps so pump and discharge pipe disconnecting flanges make positive seals when pumps are lowered into place.
- E. Install pump basins and connect to drainage and vent piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or collapse during concrete placement. Set basin cover and fasten to basin top flange. Install cover so top surface is flush with finished floor.
- F. Install packaged, submersible single fixture style units and make direct connections to drainage and vent piping.
- G. Install elevator sump pumps in elevator pit sumps. Connect to drainage piping as per the Drawings. Install control panels in adjacent elevator machine rooms unless otherwise indicated on the Drawings.
- H. Support piping so weight of piping is not supported by pumps.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Division 15 Section "Plumbing Piping and Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to sewage pumps to allow service and maintenance.
- C. Connect drainage and vent piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping. Install vent piping equal to or greater than size of pump basin vent connection. Refer to Division 15 Section "Plumbing Piping and Specialties."

1. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping.
- D. Ground equipment according to Division 16 Section "Grounding and Bonding."
- E. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Verify bearing lubrication.
 3. Disconnect couplings and check motors for proper direction of rotation.
 4. Verify that each pump is free to rotate by hand. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 5. Verify that pump controls are correct for required application.
- B. Start pumps without exceeding safe motor power:
 1. Start motors.
 2. Open discharge valves slowly.
 3. Check general mechanical operation of pumps and motors.
- C. Test and adjust controls and safeties.
- D. Remove and replace damaged and malfunctioning components.
 1. Pump Controls: Set pump controls for automatic start, stop, and alarm operation as required for system application.
 2. Set field-adjustable switches and circuit-breaker trip ranges as indicated, or if not indicated, for normal operation.
- E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION

SECTION 15485

ELECTRIC DOMESTIC WATER HEATERS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by this Section.

1.2 SUMMARY

- A. This Section includes the following for domestic water systems:
 - 1. Residential, electric water heaters.
 - 2. Expansion tanks.
 - 3. Accessories.
- B. Related Sections include the following:
 - 1. Division 15 Section "Meters and Gages" for thermometers, flow meters, and pressure and vacuum gages.

1.3 DEFINITIONS

- A. Type I Lining: Spray-on and baked internal glass tank lining, (includes epoxy-phenolic and polymerized epoxy); and others deemed as equal by the Architect.
 - 1. Anode rod(s) required and provided.

1.4 SUBMITTALS

- A. General: See Division 1 for general submittal and product substitution requirements.
- B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.
 - 1. Product Data: For each type and size of water heater. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

2. Shop Drawings: Detail water heater assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Wiring Diagrams: Power, signal, and control systems. Differentiate between manufacturer-installed and field-installed wiring.
 4. Product Certificates: Signed by manufacturers of water heaters certifying that products furnished comply with requirements.
 5. Warranty data.
- C. Post Construction Submittals: Submit the following items upon completion of system installations.
1. Maintenance Data: For water heaters to include in maintenance manuals specified in Division 1.
 2. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on specific units indicated. Other manufacturers' products complying with requirements may be considered. Refer to Division 1 Section "Substitutions."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. ASHRAE Standards: Comply with performance efficiencies prescribed for the following:
 1. ASHRAE 90.2, "Energy Efficient Design of New Low-Rise Residential Buildings," for household water heaters.

1.6 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of water heaters that fail in materials or workmanship within specified warranty period.
- C. Heating Elements: Include a 5 year warranty from date of Substantial Completion.
- D. Tank and Lining: Include a 5 year warranty from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Residential Storage Electric Water Heaters, Type I Lining:
 - 1. Bradford White Corp.
 - 2. Lochinvar Corp.
 - 3. Rheem Manufacturing Co.; Ruud Water Heater Div.
 - 4. Smith: A. O. Smith Water Products Co.
 - 5. State Industries.
- C. Expansion Tanks:
 - 1. Amtrol, Inc.
 - 2. Armstrong Pumps, Inc.
 - 3. Smith: A. O. Smith; Aqua-Air Div.
 - 4. Taco, Inc.
 - 5. Wessels Co.
- D. Water Heater Stand and Drain Pan Units:
 - 1. Safety: W. H. Safety Products, Inc.

2.2 RESIDENTIAL STORAGE ELECTRIC WATER HEATERS

- A. Description: Comply with UL 174.
- B. Storage Tank Construction: Steel with 150-psig (1035-kPa) working-pressure rating.
 - 1. Tappings: Factory fabricated of materials compatible with tank for piping connections, relief valve, drain, anode rod, and controls as required. Attach tappings to tank before testing and labeling. Include ASME B1.20.1, pipe thread.
 - 2. Interior Finish: Materials and thicknesses complying with NSF 61, barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.
 - a. Type I.
 - 3. Insulation: Comply with ASHRAE 90.2. Surround entire storage tank except connections and controls.
 - 4. Jacket: Steel, with enameled finish.
- C. Heating Elements: Electric, screw-in, immersion type.
 - 1. Temperature Control: Adjustable thermostat for each element with wiring arrangement for non-simultaneous operation.
- D. Anode Rod: Factory installed, magnesium.
- E. Dip Tube: Factory installed. Not required if cold-water inlet is near bottom of storage tank.

- F. Drain Valve: ASSE 1005, factory installed.
- G. Basis of Design: As scheduled on the Drawings.

2.3 EXPANSION TANKS

- A. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
- B. Construction: 150-psig (1035-kPa) working-pressure rating.
- C. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1, pipe thread.
- D. Tank Interior Finish: Materials and thicknesses complying with NSF 61, barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.
- E. Tank Exterior Finish: Manufacturer's standard, unless finish is indicated.
- F. Air-Charging Valve: Factory installed.
- G. Basis of Design: As scheduled on the Drawings.

2.4 WATER HEATER ACCESSORIES

- A. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into tank.
 - 1. Option: Separate temperature and pressure relief valves are acceptable instead of combination relief valve.
 - 2. Exception: Omit combination temperature and pressure relief valve for tankless water heater, and furnish pressure relief valve for installation in piping.
- B. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than heat-exchanger working-pressure rating.
- C. Vacuum Relief Valves: Comply with ASME PTC 25.3. Furnish for installation in piping.
- D. Water Heater Stand and Drain Pan Units: High-density-polyethylene-plastic, 18-inch- (457-mm-) high, enclosed-base stand complying with IAPMO PS 103 and IAS No. 2. Include integral or separate drain pan with raised edge and NPS 1-1/4 drain outlet with ASME B1.20.1, pipe thread.
- E. Water Heater Stands: Water heater manufacturer's factory-fabricated, steel stand for floor mounting and capable of supporting water heater and water. Include dimension that will support bottom of water heater a minimum of 18 inches (457 mm) above the floor.

- F. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated, steel bracket for wall mounting and capable of supporting water heater and water.
- G. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of water heater and include drain outlet not less than NPS 1-1/4.
- H. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE 90.1 or ASHRAE 90.2.
 - 1. Application: Required at connections to heaters in non-circulated systems.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

- A. Install water heaters, level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- B. Anchor water heaters to substrate.
- C. Install temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend relief valve outlet with water piping in continuous downward pitch and discharge onto closest floor drain.
- D. Install pressure relief valves in water piping for water heaters without storage. Extend relief valve outlet with water piping in continuous downward pitch and discharge into janitor sink, MR-A.
- E. Install vacuum relief valves in cold-water-inlet piping.
- F. Install water heater drain piping as indirect waste to spill into mop sink or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 15 Section "Plumbing Specialties" for drain valves.
- G. Install thermometers on water heater inlet and outlet piping. Refer to Division 15 Section "Meters and Gages" for thermometers.
 - 1. Exception: Omit thermometers for the following:
 - a. Residential, water heater inlet and outlet piping.
- H. Fill water heaters with water.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.

- C. Connect hot- and cold-water piping with shutoff valves and unions.
- D. Make connections with dielectric fittings where piping is made of dissimilar metal.
- E. Electrical Connections: Power wiring and disconnect switches are specified in Division 16 Sections. Arrange wiring to allow unit service.
- F. Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

- A. In addition to manufacturer's written installation and startup checks, perform the following:
 - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 2. Verify that piping system tests are complete.
 - 3. Check for piping connection leaks.
 - 4. Check for clear relief valve inlets, outlets, and drain piping.
 - 5. Test operation of safety controls, relief valves, and devices.
 - 6. Energize electric circuits.
 - 7. Adjust operating controls.
 - 8. Adjust hot-water-outlet temperature settings. Do not set above 140 deg F (60 deg C) unless piping system application requires higher temperature.

END OF SECTION

SECTION 15513

CONDENSING BOILERS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, condensing boilers, trim, and accessories for generating hot water.

1.3 SUBMITTALS

- A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
 - 1. Wiring Diagrams: Detail power, signal, and control wiring.
- B. Startup service reports.
- C. Operation and Maintenance Data: For condensing boilers to include in emergency, operation, and maintenance manuals.
- D. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of condensing boilers 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. ASME Compliance: Fabricate and label condensing boilers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. ASHRAE/IESNA 90.1-1999 Compliance: Condensing boilers shall have minimum efficiency according to Table 6.2.1F.
- E. UL Compliance: Test condensing boilers to comply with UL 795, "Commercial-Industrial Gas Heating Equipment."

1.5 COORDINATION

- A. 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. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing boilers that fail in materials or workmanship within specified warranty period.
- B. Warranty Period for Fire-Tube Condensing Boilers:
 - 1. Leakage and Materials: Ten (10) years from date of Substantial Completion.
 - 2. Heat Exchanger Damaged by Thermal Stress and Corrosion: Nonprorated for five (5) years from date of Substantial Completion.
- C. Warranty Period for Water-Tube Condensing Boilers: Twenty (20) years from date of Substantial Completion.
- D. Warranty Period for Water-Jacketed Condensing Boilers:
 - 1. Leakage and Materials: Eight (8) years from date of Substantial Completion.
 - 2. Heat Exchanger Damaged by Thermal Stress and Corrosion: Nonprorated for five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Fire-Tube Condensing Boilers:
 - a. Cleaver-Brooks - Clearfire
 - 2. Water-Jacketed Condensing Boilers:

- a. Viessmann Mfg. Co. (US) Inc.

2.2 FIRE-TUBE CONDENSING BOILERS

- A. Description: Factory-fabricated, -assembled, and -tested fire-tube condensing boiler with heat exchanger sealed pressure-tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.
- B. Fire-Tube Boiler Components:
 1. Heat Exchanger: Ferrous and nonferrous, corrosion-resistant combustion chamber.
 2. Pressure Vessel: Carbon steel with welded heads and tube connections.
 3. Burner: Natural gas, forced draft.
 4. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
 5. Gas Train: Combination gas valve with manual shutoff and pressure regulator – system to operate at 14" W.G. . Include 100 percent safety shutoff with electronic flame supervision.
 6. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
 7. Casing:
 - a. Control Compartment Enclosures: NEMA 250, Type 1A.
 - b. Finish: Baked-enamel protective finish.
 - c. Insulation: Minimum 2-inch- (50-mm-) thick insulation surrounding the heat exchanger.
 - d. Combustion-Air Connections: Inlet and vent duct collars.
 8. Mounting base to secure boiler to concrete base.

2.3 WATER-JACKETED CONDENSING BOILERS

- A. Description: Factory-fabricated, -assembled, and -tested water-jacketed condensing boiler with heat exchanger sealed pressure-tight, built on a steel base; including insulated jacket; flue-gas vent; water supply, return, and condensate drain connections; and controls. Water heating service only.
- B. Water-Jacketed Boiler Components:
 1. Heat Exchanger: Stainless-steel primary and secondary combustion chamber.
 2. Pressure Vessel: Carbon steel with welded heads and tube connections where not in contact with combustion or flue gases.
 3. Burner: Natural gas, forced draft; swing-open front and burner observation port.
 4. Blower: Centrifugal fan, forced draft. Include prepurge and postpurge of the combustion chamber.

- a. Refer to Division 15050 "Basic Mechanical Materials and Methods"; Section "Motors for Mechanical Equipment" for general requirements.
5. Gas Train: Combination gas valve with manual shutoff and pressure regulator – system to operate at 14" W.G. Include 100 percent safety shutoff with electronic flame supervision.
6. Ignition: Electric-spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
7. Casing:
 - a. Jacket: Sheet metal, with snap-in or interlocking closures.
 - b. Control Compartment Enclosures: NEMA 250, Type 1A.
 - c. Finish: Powder-coated protective finish.
 - d. Insulation: Minimum 4-inch- (100-mm-) thick fiberglass insulation surrounding the heat exchanger.
 - e. - Combustion-Air Connections: Inlet and vent duct collars.
8. Mounting base to secure boiler to concrete base.

2.4 HOT-WATER BOILER TRIM

- A. Include devices sized to comply with ANSI B31.9, "Building Services Piping."
- B. Aquastat Controllers: Operating, firing rate, and high limit.
- C. Safety Relief Valve: ASME rated. 30 psig (210 kPa).
 1. Pressure Setting: 20 psig.
- D. Altitude and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is at approximately 50 percent of full range.
- E. Boiler Air Vent: Automatic.
- F. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.
- G. Circulation Pump (if required): Non-overloading, horizontal, in-line pump with rubber-mounted, split-capacitor motor having thermal-overload protection and system-lubricated bearings; designed to operate at specified boiler pressures and temperatures.
- H. Expansion Tank (if part of boiler): Welded carbon steel, rated for operating pressure and temperature or minimum 125-psig (860-kPa) working pressure and 240 deg F (115 deg C) operating temperature. Separate air charge from system water to maintain design expansion capacity by a flexible butyl-rubber bladder securely sealed into tank. Include hose-end gate drain valve, pressure gage with minimum 3-inch (75-mm) dial, and air-charging fitting. Factory fabricate and test tank with taps installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

2.5 BURNER OPERATING CONTROLS

- A. Description: To maintain safe operating conditions, burner safety controls limit the operation of burner.
 - 1. High Cutoff: Automatic reset stops burner if operating conditions rise above maximum boiler design temperature.
 - 2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be automatic-reset type.
 - 3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
 - 4. Alarm Bell: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

2.6 BOILER OPERATING CONTROLS

- A. Boiler operating controls shall include the following devices and features:
 - 1. Control Transformer: 115 V.
 - 2. Sequence of Operation: Electric, factory-fabricated, and field-installed panel to control burner firing rate to maintain boiler supply water temperature at 180 deg. F.
- B. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control hot water set point and display boiler status and alarms.

2.7 SOURCE QUALITY CONTROL

- A. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code: Section I, for high-pressure boilers and Section IV, for low-pressure boilers.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
 - 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical spaces for suitable conditions where boilers will be installed. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

- A. Install boilers level on concrete base. Concrete base is specified in Division 15 Section "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.
 - 1. Cast-in-place concrete materials and placement requirements are specified in Division 3.
- B. Install gas-fired boilers according to NFPA 54.
- C. Assemble and install boiler trim.
- D. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 15 Section "Basic Mechanical Materials and Methods."
- C. Connect gas piping full size to boiler gas-train inlet with union.
- D. Connect hot-water piping to supply- and high (DHW) or low (FHW) return-boiler tappings with shutoff valve and union or flange at each connection.
- E. Install piping from safety relief valves to nearest floor drain.
- F. Connect breeching full size to boiler outlet. Refer to Division 15 Section "Breechings, Chimneys, and Stacks" for venting materials. Connect condensate drain from base of breeching to closest floor drain by way of a neutralization tank, Zurn model Z9A-DT. Stock with neutralization chips.
- G. Install piping adjacent to boiler to allow service and maintenance.
- H. Ground equipment according to Division 16 Section "Grounding and Bonding."
- I. Connect wiring according to Division 16 Section "Conductors and Cables."
- J. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to test, inspect, and adjust boiler components and equipment installation and to perform startup service.

- B. Perform installation and startup checks according to manufacturer's written instructions.
- C. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
- D. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
- E. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- F. Adjust initial temperature set points.
- G. Set field-adjustable switches and circuit breaker trip ranges as indicated.
- H. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.
- I. Prepare written report that documents testing procedures and results.

3.5 DEMONSTRATION

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

END OF SECTION

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SECTION 15550

BREECHINGS, CHIMNEYS, AND STACKS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Listed double-wall vent and chimney.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Building-heating-appliance chimneys.
- B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.
- C. Welding certificates.
- D. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain listed system components through one source from a single manufacturer.

- B. Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.
 - C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.
- 1.5 COORDINATION
- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."
- 1.6 WARRANTY
- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Listed building-heating-appliance chimneys (**Chimney submitted shall first be approved by the approved boiler manufacturer**).
 - a. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
 - b. Security Chimneys Ltd.

2.2 LISTED BUILDING-HEATING-APPLIANCE CHIMNEYS

- A. Double wall: 316L stainless steel or DCV AL-294C with plasma welded seams. Joints made by sealing with a high temperature silicone and applying a locking band (supplied) with a ceramic fiber gasket.
- B. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, above roof brace, thimbles, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - 1. Termination: Exit cone with drain section incorporated into riser.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF LISTED VENTS AND CHIMNEYS

- A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
- B. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
- C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
- D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
- E. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.
- F. Erect stacks plumb to finished tolerance of no more than 1 inch (25 mm) out of plumb from top to bottom.

3.3 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.
- B. Clean breechings internally, during and after installation, to remove dust and debris.
- C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION

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SECTION 15671

CONDENSING UNITS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.
- D. The requirements of Section 15071, "Mechanical Vibration and Seismic Controls" apply to the installation of equipment defined by this section.

1.2 SUMMARY

- A. This Section includes air-cooled condensing units.

1.3 SUBMITTALS

- A. Product Data: For each condensing unit, include rated capacities, operating characteristics, furnished specialties, and accessories. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer.
 - 1. Design Calculations: Calculate requirements for selecting vibration isolators for designing vibration isolation bases.
 - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
 - 3. Wiring Diagrams: Power, signal, and control wiring.
- C. Operation and Maintenance Data: For condensing units to include in emergency, operation, and maintenance manuals.
- D. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of condensing units 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. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Code for Mechanical Refrigeration."

1.5 COORDINATION

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."
- B. Coordinate location of piping and electrical rough-ins.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within one year warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Compressor failure.
 - b. Condenser coil leak.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Condensing Units, Air Cooled, 6 to 120 Tons (21 to 422 kW)
 - a. McQuay International.
 - b. York
 - c. Trane
 - d. Carrier

2.2 CONDENSING UNITS, AIR COOLED, 6 TO 120 TONS (21 TO 422 kW)

- A. Description: Factory assembled and tested, air-cooled; consisting of casing, compressors, condenser coils, condenser fans and motors, and unit controls.
- B. Compressor: Hermetic compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.
- C. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including subcooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrates by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.
- D. Condenser Fans: Propeller-type vertical discharge, either directly or belt driven. Include the following:
 - 1. Permanently lubricated ball-bearing motors.
 - 2. Separate motor for each fan.
 - 3. Dynamically and statically balanced fan assemblies.
- E. Operating and safety controls include the following:
 - 1. Manual-reset, high-pressure cutout switches.
 - 2. Automatic-reset, low-pressure cutout switches.
 - 3. Low oil pressure cutout switch.
 - 4. Compressor-winding thermostat cutout switch.
 - 5. Three-leg, compressor-overload protection.
 - 6. Control transformer.
 - 7. Magnetic contactors for compressor and condenser fan motors.
 - 8. Timer to prevent excessive compressor cycling.
- F. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include the following:
 - 1. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
 - 2. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
 - 3. Gasketed control panel door.
 - 4. Nonfused disconnect switch, factory mounted and wired, for single external electrical power connection.
 - 5. Condenser coil grille to protect coil from physical damage.

2.3 MOTORS

- A. Comply with requirements in Division 15, Section 15050 Basic Mechanical Materials and Methods, "Motors for Mechanical Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 16 Sections.

2.4 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate condensing units according to ARI 340/360.
 1. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- B. Test and inspect shell and tube condensers according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- C. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of condensing units.
- B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine concrete pad for suitable conditions where condensing units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances to the degree permitted by the building constraints.
- B. Vibration Isolation: Mount condensing units on restrained spring isolators with a minimum deflection of one inch. Vibration isolation devices and installation requirements are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."
- C. Maintain manufacturer's recommended clearances for service and maintenance to the degree permitted by the building constraints.
- D. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect refrigerant piping to air-cooled condensing units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Division 15 Section "Refrigerant Piping."
- D. Ground equipment according to Division 16 Section "Grounding and Bonding."
- E. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform electrical test and visual and mechanical inspection.
 - 2. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. Verify proper airflow over coils.
- B. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
- C. Remove and replace malfunctioning condensing units and retest as specified above.

3.5 STARTUP SERVICE

- A. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - 1. Inspect for physical damage to unit casing.
 - 2. Verify that access doors move freely and are weather-tight.
 - 3. Clean units and inspect for construction debris.
 - 4. Verify that all bolts and screws are tight.
 - 5. Adjust vibration isolation and flexible connections.
 - 6. Verify that controls are connected and operational.
- B. Lubricate bearings on fans.
- C. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.

- D. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.
- E. Measure and record airflow over coils.
- F. Verify proper operation of condenser capacity control device.
- G. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
- H. After startup and performance test, lubricate bearings.

END OF SECTION

SECTION 15725

MODULAR INDOOR AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.
- D. The requirements of Section 15071, "Mechanical Vibration and Seismic Controls" apply to the installation of equipment defined by this section.

1.2 SUMMARY

- A. This Section includes variable-air-volume, modular air-handling units with coils for indoor installations.

1.3 SUBMITTALS

- A. Product Data: For each type of modular indoor air-handling unit indicated. Include the following:
 - 1. Certified fan-performance curves with system operating conditions indicated.
 - 2. Certified fan-sound power ratings.
 - 3. Certified coil-performance ratings with system operating conditions indicated.
 - 4. Motor ratings, electrical characteristics, and motor and fan accessories.
 - 5. Material gages and finishes.
 - 6. Filters with performance characteristics.
 - 7. Dampers, including housings, linkages, and operators.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer.
 - 1. Design Calculations: Calculate requirements for selecting vibration isolators for designing vibration isolation bases.
 - 2. Wiring Diagrams: Power, signal, and control wiring.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain modular indoor air-handling units through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of modular indoor air-handling units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. NFPA Compliance: Modular indoor air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
- E. ARI Certification: Modular indoor air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
- F. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate size and location of structural-steel support members.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Carrier; Div. of United Technologies Corp.
 - 2. CES Group Inc.; Governair, Mammoth, Temtrol, Venmar Ventrol, Webco Divisions.
 - 3. Dunham-Bush, Inc.
 - 4. McQuay International.
 - 5. Trane Company (The); Worldwide Applied Systems Group.
 - 6. York International Corporation.

2.2 MANUFACTURED UNITS

- A. Modular indoor air-handling units shall be factory assembled and consist of fans, motor and drive assembly, coils, damper, plenums, filters, condensate pans, mixing dampers, control devices, and accessories.

2.3 CABINET

- A. Materials: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

- 1. Outside Casing: Galvanized steel, 0.0516 inch (1.3 mm) thick.
- 2. Inside Casing: Galvanized steel, 0.0276 inch (0.7 mm) thick.
- 3. Floor Plate: Galvanized steel, 0.1382 inch (3.5 mm) thick.

- B. Cabinet Insulation: Comply with NFPA 90A or NFPA 90B.

- 1. Materials: ASTM C 1071 with coated surface exposed to airstream to prevent erosion of glass fibers.
- 2. Thickness: 2 inches (50 mm).
- 3. Thermal Conductivity (k-Value): 0.26 at 75 deg F (0.037 at 24 deg C) mean temperature.
- 4. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50, when tested according to ASTM C 411.
- 5. Location and Application: Encased between outside and inside casing.

- C. Access Panels and Doors: Same materials and finishes as cabinet complete with hinges, latches, handles, and gaskets. Inspection and access panels and doors shall be sized and located to allow periodic maintenance and inspections. Provide access panels and doors in the following locations:

- 1. Fan Section: Door.
- 2. Access Section: Door.
- 3. Filter Section: Door to allow periodic removal and installation of filters.

- D. Condensate Drain Pans: Formed sections of stainless-steel sheet complying with requirements in ASHRAE 62. Fabricate pans with slopes in two planes to collect condensate from cooling coils (including coil piping connections and return bends) and to collect entrained rain and snow in the mixing boxes when units are operating at maximum catalogued outside air.

- 1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
- 2. Drain Connections: Both ends of pan. Supply one drain connection plug per pan.

2.4 FAN SECTION

- A. Fan-Section Construction: Belt-driven centrifugal fan consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure and equipped with

formed-steel channel base for integral mounting of fan, motor, and casing panels. Mount fan with vibration isolation. Provide service light with wired switch on the exterior of the cabinet.

- B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and access doors or panels to allow entry to internal parts and components.
 - 1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 - 2. Performance Class: AMCA 99-2408, Class I.
 - 3. Horizontal Flanged Split Housing: Bolted construction.
 - 4. Plug Fans: With steel cabinet. Fabricate without fan scroll and volute housing.
- C. Fan Assemblies: Statically and dynamically balanced at all fan speeds and motor horsepower that the fan will encounter within the range of the VFD.
- D. Shafts: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - 1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
 - 2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- E. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
 - 1. Ball-Bearing Rating Life: ABMA 9, L_{50} of 200,000 hours.
- F. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation and with 1.5 service factor based on fan motor.
 - 1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - 2. Belts: Oil resistant, nonsparking, and nonstatic; matched for multiple belt drives.
 - 3. Belt Guards: Fabricate to OSHA/SMACNA requirements; 0.1046-inch- (2.7-mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen welded to steel angle frame or equivalent; prime coated.
 - 4. Motor Mount: Adjustable for belt tensioning.
- G. Fan-Section Source Quality Control:
 - 1. Sound Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
 - 2. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

2.5 MOTORS

- A. Comply with requirements in Division 15, Section 15050 Basic Mechanical Materials and Methods, "Motors for Mechanical Equipment."
- B. Noise Rating: Quiet.

2.6 COILS

- A. Coil Sections: Common or individual, insulated, galvanized-steel casings for heating and cooling coil. Design and construct to facilitate removal and replacement of coil for maintenance and to ensure full airflow through coils.
- B. Water Coils: Continuous circuit coil fabricated according to ARI 410.
 - 1. Piping Connections: Threaded, on same end.
 - 2. Tubes: Copper.
 - 3. Fins: Aluminum with baked epoxy coating.
 - 4. Fin and Tube Joint: Mechanical bond.
 - 5. Headers: Seamless copper tube with brazed joints, prime coated.
 - 6. Frames: Galvanized-steel channel frame.
 - 7. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
 - a. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
 - 8. Source Quality Control: Test to 300 psig (2070 kPa) and to 200 psig (1380 kPa) underwater.
- C. Refrigerant Coils: Coil designed for use with R-22 refrigerant, fabricated according to ARI 410, connected with brazed fittings.
 - 1. Tubes: Copper.
 - 2. Fins: Aluminum with baked epoxy coating.
 - 3. Fin and Tube Joint: Mechanical bond.
 - 4. Suction and Distributor: Seamless copper tube with brazed joints.
 - 5. Frames: Galvanized-steel channel frame.
 - 6. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
 - a. Working-Pressure Rating: 300 psig (2070 kPa).
 - 7. Source Quality Control: Test to 450 psig (3105 kPa) and to 300 psig (2070 kPa) underwater.

2.7 DAMPERS

- A. General: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm (10-m/s) face velocity through damper and 4-inch wg (1000-Pa) pressure differential.

- B. Damper Operators: Electric specified in Division 15 Section "HVAC Instrumentation and Controls."
- C. Combination Filter and Mixing Box: Parallel-blade galvanized-steel dampers mechanically fastened to steel operating rod in reinforced, galvanized-steel cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat permanent or throwaway filters. Provide hinged access panels or doors to allow removal of filters from both sides of unit.

2.8 FILTER SECTION

- A. Filters: Comply with NFPA 90A.
- B. Filter Section: Provide filter holding frames arranged for flat or angular orientation, with access door on side of unit. Filters shall be removable from one side. Provide magnahelic filter gauge across filter bank to give an analog reading of the static pressure drop across the filters. Mount gauge on outside of unit in proximity to the filters.
- C. Extended-Surface, Disposable Panel Filters: Factory-fabricated, dry, extended-surface filters with holding frames.
 - 1. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
 - 2. Media and Media-Grid Frame: Nonflammable cardboard.
 - 3. Filter-Media Frame: Nonflammable cardboard.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of DX, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Concrete Bases: Install floor mounted units on 4-inch- (100-mm-) high concrete bases. See Division 15 Section "Basic Mechanical Materials and Methods" for concrete base materials and fabrication requirements.

- B. Install modular indoor air-handling units with the following vibration control devices. Vibration control devices are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."
 - 1. Units with Internally Isolated Fans: Secure units to concrete bases.
 - 2. Floor-Mounted Units: Support on concrete bases using housed-spring isolators. Secure units to anchor bolts installed in concrete bases.
- C. Arrange installation of units to provide access space around modular indoor air-handling units for service and maintenance.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to modular indoor air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using NPS 1-1/4 (DN 32), Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot-Water Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping." Connect to supply and return coil tappings with shutoff or balancing valve and union or flange at each connection.
- F. Refrigerant Piping: Comply with applicable requirements in Division 15 Section "Refrigerant Piping." Connect to supply and return coil tappings with shutoff valve and union or flange at each connection.
- G. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.
- H. Electrical: Comply with applicable requirements in Division 16 Sections for power wiring, switches, and motor controls.
- I. Ground equipment according to Division 16 Section "Grounding and Bonding."
- J. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
1. Leak Test: After installation, fill water coils with water and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
 2. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 STARTUP SERVICE

- A. Final Checks before Startup: Perform the following:
1. Verify that shipping, blocking, and bracing are removed.
 2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 3. Perform cleaning and adjusting specified in this Section.
 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
 6. Set face-and-bypass dampers to full face flow.
 7. Set outside- and return-air mixing dampers to minimum outside-air setting.
 8. Comb coil fins for parallel orientation.
 9. Install clean filters.
 10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for modular indoor air-handling units include the following:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
 2. Measure and record motor electrical values for voltage and amperage.
 3. Manually operate dampers from fully closed to fully open position and record fan performance.
- C. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for modular indoor air-handling system testing, adjusting, and balancing.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

3.7 CLEANING

- A. Clean modular indoor air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.
- B. After completing system installation and testing, adjusting, and balancing modular indoor air-handling and air-distribution systems, clean filter housings and install new filters.

END OF SECTION

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SECTION 15764

RADIATORS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Convectors and Floor-vectors.
 - 2. Finned-tube radiators.

1.3 SUBMITTALS

- A. Product Data: Include specialties and accessories for each radiator type.
- B. Shop Drawings: Show the following:
 - 1. Plans, elevations, sections, and details.
 - 2. Required clearances.
 - 3. Location and size of each field connection.
 - 4. Enclosure joints, corner pieces, access doors, and other accessories.
 - 5. Method of attaching hangers to building structure.
 - 6. Unit schedules to include rated capacities, furnished specialties, and accessories.
- C. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied color finishes.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Convectors:

- a. Burnham Corp.; Hydronics Div.
- b. Dunham-Bush, Inc.
- c. Engineered Air.
- d. Rosemex Products.
- e. Sterling Heating Equipment.
- f. Trane Company (The); North American Commercial Group.

2. Finned-Tube Radiators:

- a. Dunham-Bush, Inc.
- b. Engineered Air.
- c. Haydon Corp.
- d. Rosemex Products.
- e. Slant/Fin.
- f. Sterling Heating Equipment.
- g. Trane Company (The); North American Commercial Group.

3. Floor-Vectors:

- a. Beacon-Morris
- b. Haydon

2.2 CONVECTORS

A. Convector Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and cast-brass headers; steel side plates and supports; factory-pressure tested at 100 psig (690 kPa) underwater.

B. Enclosures: Steel with exposed corners rounded; removable front panels with tamperproof fasteners braced and reinforced for stiffness.

1. Front and Top: 0.0598-inch- (1.5-mm-) thick steel.
2. Back and Ends: 0.0478-inch- (1.2-mm-) thick steel.
3. Insulation: 1/2-inch- (13-mm-) thick, fibrous glass on inside at front, sides, and back of enclosure.
4. Finish: Factory-applied baked enamel in manufacturer's standard color.
5. Enclosure Style: fully-recessed, wall-mounted with four-sided front cover.

- C. Capacity: As scheduled, based on 50 deg F (10 deg C) entering air temperature, 110 deg F (43 deg C) average water temperature.

2.3 FINNED-TUBE RADIATORS

- A. Heating Elements: Seamless copper tubing suitable for soldered fittings, mechanically expanded into evenly spaced aluminum fins.
 - 1. Tube Diameter: NPS 1-1/4 (DN 32).
 - 2. Fin Size: 3-1/4 by 5-1/4 inches (83 by 133 mm).
- B. Element Hangers: Ball-bearing cradle type with unrestricted longitudinal movement on enclosure brackets.
- C. Enclosures: Enameled steel with easily jointed components for wall-to-wall installation, rigidly supported on wall- or floor-mounting brackets.
 - 1. Enclosures 12 Inches (300 mm) and Less in Height: 18 gauge [0.0478-inch- (1.2-mm-)] thick steel.
 - 2. Support Brackets: Locate at maximum 36-inch (1000-mm) spacing.
 - 3. Finish: Factory-applied baked enamel in manufacturer's standard color.
 - 4. Enclosure Style: Sloped top.
- D. Capacity: As scheduled, based on 65 deg F (18 deg C) entering air temperature, 110 deg F (43 deg C) average water temperature.

2.4 FLOOR-VECTORS

- A. Convectector Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and cast-brass headers; steel side plates and supports; factory-pressure tested at 100 psig (690 kPa) underwater.
- B. Enclosures: Steel with exposed corners rounded; removable floor grills with tamperproof fasteners braced and reinforced for stiffness.
 - 1. Front and Top: 0.0598-inch- (1.5-mm-) thick steel.
 - 2. Back and Ends: 0.0478-inch- (1.2-mm-) thick steel.
 - 3. Insulation: 1/2-inch- (13-mm-) thick, fibrous glass on inside at front, sides, and back of enclosure.
 - 4. Finish: Factory-applied baked enamel in manufacturer's standard color.
 - 5. Enclosure Style: fully-recessed, floor-mounted with four-sided front cover and extruded aluminum or brass grille for the floor opening.

- 2.5 Capacity: As scheduled, based on 50 deg F (10 deg C) entering air temperature, 110 deg F (43 deg C) average water temperature.
- 2.6 SOURCE QUALITY CONTROL
- A. Factory test and rate finned-tube radiators according to Hydronics Institute's "Testing and Rating Standard for Finned-Tube (Commercial) Radiation."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install radiators level and plumb.
- B. Install finned-tube radiators as follows:
1. Unless otherwise indicated, center heating elements and enclosure under windows.
 2. Unless otherwise indicated, install enclosure continuously from wall to wall.
 3. Unless otherwise indicated, install enclosure continuously around corners, using outside and inside corner fittings.
 4. Join sections with splice plates and filler pieces to provide continuous enclosure.
 5. Terminate enclosures with manufacturer's end caps.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect hot-water units and components to piping according to Division 15 Section "Hydronic Piping."
- C. Install shutoff valve on inlet and balancing valve on outlet.

3.3 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect for damage to exposed finish. Repair damaged finish to match original finish.

END OF SECTION

SECTION 15766

CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes cabinet unit heaters.

1.3 SUBMITTALS

- A. Product Data: Include specialties and accessories for each unit type and configuration.
- B. Shop Drawings: Submit the following for each unit type and configuration:
 - 1. Plans, elevations, sections, and details.
 - 2. Details of anchorages and attachments to structure and to supported equipment.
 - 3. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
 - 4. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
- C. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied color finishes.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Airtherm Manufacturing Company.
 2. Carrier Corp.
 3. Dunham-Bush, Inc.
 4. International Environmental Corp.
 5. McQuay International.
 6. Sterling HVAC Products
 7. Trane Company (The); North American Commercial Group.

2.2 CABINET UNIT HEATERS

- A. Description: An assembly including filter, chassis, coil, fan, and motor in blow-through configuration with heating coil.
- B. Cabinet: For one or more of the following configurations:
1. Recessed or wall-mounted with front grilles for air inlet and outlet.

2.3 MATERIALS

- A. Chassis: Galvanized steel, with flanged edges.
- B. Coil Section Insulation: 1-inch (25-mm) duct liner complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
1. Fire-Hazard Classification: Duct liner and adhesive shall have a maximum flame-spread rating of 25 and smoke-developed rating of 50 when tested according to ASTM E 84.
- C. Cabinet: Galvanized steel, with removable panels fastened with tamperproof fasteners.
- D. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer with manufacturer's standard paint, in color selected by Architect, applied to factory-assembled and -tested cabinet unit heater before shipping.

2.4 COILS

- A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and with manual air vent. Coils shall be rated for a minimum working pressure of 300 psig (2068 kPa) and a maximum entering water temperature of 275 deg F (135 deg C), with manual air vent.

2.5 FAN

- A. Centrifugal, with forward-curved, double-width wheels and fan scrolls made of galvanized steel or thermoplastic material, directly connected to motor.

2.6 FAN MOTORS

- A. Comply with requirements in Division 15, Section 15050 Basic Mechanical Materials and Methods, "Motors for Mechanical Equipment."
- B. Multispeed motor with integral thermal-overload protection and resilient mounts. Connect motor to chassis wiring with plug connection.

2.7 ACCESSORIES

- A. Steel recessing flanges for recessing cabinet unit heaters into wall.
- B. Filters: 1-inch- (25-mm-) thick, glass-fiber media in fiberboard frame.

2.8 CONTROLS

- A. Control Devices: Unit-mounted fan-speed switch and thermostat.

2.9 SOURCE QUALITY CONTROL

- A. Test cabinet unit heater coils according to ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before cabinet unit heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install cabinet unit heaters level and plumb.
- B. Install cabinet unit heaters to comply with NFPA 90A.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
- C. Install piping to allow service and maintenance.
- D. Ground equipment.
- E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing and report results in writing:
 - 1. After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties.
- B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5 CLEANING

- A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. After installing units, clean cabinet unit heaters internally according to manufacturer's written instructions.
- C. Install new filters in each cabinet unit heater within two weeks after Substantial Completion.

END OF SECTION

SECTION 15767

PROPELLER UNIT HEATERS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes propeller unit heaters.

1.3 SUBMITTALS

- A. Product Data: Include specialties and accessories for each unit type and configuration.
- B. Shop Drawings: Submit the following for each unit type and configuration:
 - 1. Plans, elevations, sections, and details.
 - 2. Details of anchorages and attachments to structure and to supported equipment.
 - 3. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
 - 4. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
- C. Field Test Reports: Written reports of tests specified in Part 3 of this Section.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Airtherm Manufacturing Company.
2. Carrier Corp.
3. Dunham-Bush, Inc.
4. International Environmental Corp.
5. McQuay International.
6. Sterling Company
7. Trane Company (The); North American Commercial Group.
8. U S A Coil & Air Inc.

2.2 UNIT HEATERS

- A. Description: An assembly including casing, coil, fan, and motor in horizontal discharge configuration with horizontal, adjustable louvers in blow-through configuration.

2.3 MATERIALS

- A. Casing: Galvanized steel, with removable panels.
- B. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer and manufacturer's standard paint applied to factory-assembled and -tested propeller unit heater before shipping.

2.4 COILS

- A. Hot-Water Coil: Copper tube, 0.031-inch (0.78-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering water temperature of 325 deg F (163 deg C), with manual air vent. Test for leaks to 375 psig (2690 kPa) underwater.

2.5 FAN

- A. Propeller with aluminum blades directly connected to motor.

2.6 FAN MOTORS

- A. Comply with requirements in Division 15 Section "Motors."

2.7 ACCESSORIES

- A. Horizontal Configuration: Louver fin diffuser.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before propeller unit heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install propeller unit heaters level and plumb.
- B. Install propeller unit heaters to comply with NFPA 90A.
- C. Suspend propeller unit heaters from structure with rubber-in-shear vibration isolators (rubber hangers). Vibration isolators are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."
- D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Unless otherwise indicated, install shutoff valve and union or flange on each connection.
- C. Install piping adjacent to machine to allow service and maintenance.
- D. Ground equipment.
- E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing and report results in writing:
 - 1. After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties.
- B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5 CLEANING

- A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. After installing units, clean propeller unit heaters internally according to manufacturer's written instructions.

END OF SECTION

SECTION 15815

METAL DUCTS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg (minus 500 to plus 2500 Pa). Metal ducts include the following:
 - 1. Rectangular ducts and fittings.
 - 2. Single-wall, round, spiral-seam ducts and formed fittings.
- B. Related Sections include the following:
 - 1. Section 15820 "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 DEFINITIONS

- A. NUSIG: National Uniform Seismic Installation Guidelines.
- B. SMACNA – Sheet Metal and Air Conditioning Contractors' National Association, Inc. – latest edition.

1.4 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to the layout or the configuration of the duct system must be specifically approved in writing by the Architect. Accompany requests for layout modifications with calculations showing that the proposed layout will provide original design results without increasing system total pressure.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Transverse joints
 - a. Ductmate Industries, Inc.
 - b. Nexus Inc.
 - c. Ward Industries, Inc.
 2. Round duct and fittings
 - a. McGill AirFlow Corporation.
 - b. SEMCO Incorporated.
 - c. Monroe Metal Mfg. Co.
 3. Duct joints -- round ducts
 - a. Ductmate Industries, Inc.
 - b. Lindab Inc

2.2 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

2.3 SEALANT MATERIALS

- A. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
- B. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- C. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
- B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
 - 1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 - 2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
 - 3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.
- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws, compatible with duct materials.
- D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
 - 3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.5 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
 - 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
 - 2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
- C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.
- D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359 inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of nonbraced panel area unless ducts are lined.

2.6 ROUND DUCT AND FITTING FABRICATION

- A. Manufacture in accordance with SMACNA HVAC Duct Construction Standards and as indicated. Provide duct material, gauges, reinforcement, and sealing for operating pressures indicated.
- B. All duct and fittings shall be manufactured by a company whose primary business is the manufacture of spiral duct and fittings and who has been in business for at least 10 years. All spiral duct and fittings shall be manufactured by the same firm and shall be as shown on the contract drawings.
- C. Round, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- D. Duct Joints:
 - 1. Ducts up to 20 Inches (500 mm) in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
 - 2. Ducts 21 to 72 Inches (535 to 1830 mm) in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
 - 3. Round Ducts: Prefabricated connection system consisting of two roll-formed galvanized steel mating flanges with an integral sealant, galvanized steel closure ring, and neoprene gasket. Manufacture ducts according to connection system manufacturer's tolerances.
- E. Branch connections shall be made with 90 degree conical and 45 degree straight taps. All branch connections shall be made as separate fittings. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.
- F. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- G. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
 - 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible.
 - 2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg (minus 500 to plus 500 Pa):
 - a. Ducts 3 to 36 Inches (75 to 915 mm) in Diameter: 0.034 inch (0.85 mm).
 - 3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg (500 to 2500 Pa):
 - a. Ducts 3 to 26 Inches (75 to 660 mm) in Diameter: 0.034 inch (0.85 mm).

4. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
5. Round Elbows 12 Inches (200 mm) and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
6. Round Elbows 9 through 14 Inches (225 through 355 mm) in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
7. Round Elbows Larger Than 14 Inches (355 mm) in Diameter: Fabricate gored elbows unless space restrictions require mitered elbows.
8. Die-Formed Elbows for Sizes through 12 Inches (200 mm) in Diameter and pressures through 10 inch wg: 24 gauge with 2-piece welded construction.
9. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
10. Pleated Elbows for Sizes through 14 Inches (355 mm) in Diameter and Pressures through 10-Inch wg (2500 Pa): 0.022 inch (0.55 mm).

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

- A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
 1. Supply Ducts: 3-inch wg.
 2. Return Ducts (Negative Pressure): 2-inch wg.
 3. Exhaust Ducts (Negative Pressure): 1-inch wg.
 4. Relief Ducts (Positive Pressure): 1-inch wg.
 5. Outside Air Intake: 1/2 -inch wg.

3.2 DUCT INSTALLATION

- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Install round ducts in lengths not less than 12 feet (3.7 m) unless interrupted by fittings.
- C. Install ducts with fewest possible joints.
- D. Install fabricated fittings for changes in directions, size, and shape and for connections.
- E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches (300 mm), with a minimum of 3 screws in each coupling.

- F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- G. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- H. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
- I. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
- J. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- K. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- L. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches (38 mm).
- M. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and fire stopping sealant. Fire and smoke dampers are specified in Division 15 Section "Duct Accessories." Fire stopping materials and installation methods are specified in Division 7 Section "Through-Penetration Firestop Systems."
- N. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
- O. Protect duct interiors from the elements and foreign materials until building is enclosed. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system. Follow SMACNA's "Duct Cleanliness for New Construction."
- P. Paint interiors of metal ducts that do not have duct liner, for 24 inches (600 mm) upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 9 painting Sections.

3.3 SEAM AND JOINT SEALING

- A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated, as required to meet requirements of the applicable energy code, and as outlined below.
 - 1. Supply Ducts – pressure classes equal to or lower than 2-inch wg:

- a. For ducts located in conditioned spaces: seal transverse joints.
 - b. For ducts located in unconditioned spaces: seal all transverse joints and longitudinal seams.
 - c. For ducts located outdoors: seal all transverse joints, longitudinal seams and duct wall penetrations.
2. Supply Ducts – pressure classes greater than 2-inch wg:
 - a. For ducts located in conditioned spaces: seal all transverse joints and longitudinal seams.
 - b. For ducts located in unconditioned spaces and outdoors: seal all transverse joints, longitudinal seams and duct wall penetrations.
 3. Return Ducts, all pressure classes:
 - a. For ducts located in conditioned spaces: seal transverse joints.
 - b. For ducts located in unconditioned spaces: seal all transverse joints and longitudinal seams.
 - c. For ducts located outdoors: seal all transverse joints, longitudinal seams and duct wall penetrations.
 4. Exhaust ducts:
 - a. For ducts located in conditioned spaces: seal all transverse joints and longitudinal seams.
 - b. For ducts located in unconditioned spaces: seal all transverse joints only.
- B. Seal ducts before external insulation is applied.
- ### 3.4 HANGING AND SUPPORTING
- A. Support horizontal ducts within 24 inches (600 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.
 - B. Support vertical ducts at maximum intervals of 16 feet (5 m) and at each floor.
 - C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
 - D. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
- ### 3.5 CONNECTIONS
- A. Make connections to equipment with flexible connectors according to Division 15 Section "Duct Accessories."
 - B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

- A. Ductwork constructed to greater than 3" w.g. class shall be leak tested.
- B. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:
 - 1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
 - 3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch wg (500 Pa) (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2- to 10-inch wg (500 to 2500 Pa). In no case shall duct leakage exceed amounts specified in the applicable energy code.
 - 4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

3.7 CLEANING NEW SYSTEMS

- A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.
- B. Use service openings, as required, for physical and mechanical entry and for inspection.
 - 1. Create other openings to comply with duct standards.
 - 2. Disconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling sections to gain access during the cleaning process.
- C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.
- D. Clean the following metal duct systems by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

F. Cleanliness Verification:

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and reinspect ducts.

END OF SECTION

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SECTION 15820

DUCT ACCESSORIES

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Volume dampers.
 - 2. Motorized control dampers.
 - 3. Turning vanes.
 - 4. Duct-mounting access doors.
 - 5. Flexible connectors.
 - 6. Flexible ducts.
 - 7. Duct accessory hardware.
- B. Related Sections include the following:
 - 1. Division 16, Section 16700, "Fire Alarm Systems" for duct-mounting smoke detectors.
 - 2. Division 15, Section 15900 "HVAC Instrumentation and Controls" for electric damper actuators.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Volume dampers.
 - 2. Motorized control dampers.
 - 3. Turning vanes.
 - 4. Duct-mounting access doors.
 - 5. Flexible connectors.
 - 6. Flexible ducts.

- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, and method of field assembly, components, and location and size of each field connection.
 - 1. Special fittings.
 - 2. Manual-volume damper installations.
 - 3. Motorized-control damper installations.
 - 4. Wiring Diagrams: Power, signal, and control wiring.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Volume dampers
 - a. Air Balance, Inc.
 - b. American Warming and Ventilating.
 - c. Flexmaster U.S.A., Inc.
 - d. McGill AirFlow Corporation.
 - e. METALAIRE, Inc.
 - f. Nailor Industries Inc.
 - g. Penn Ventilation Company, Inc.
 - h. Ruskin Company.
 - i. Vent Products Company, Inc.
 - 2. Motorized control dampers
 - a. Air Balance, Inc.
 - b. American Warming and Ventilating.
 - c. CESCO Products.
 - d. Duro Dyne Corp.
 - e. Greenheck.
 - f. McGill AirFlow Corporation.
 - g. METALAIRE, Inc.
 - h. Nailor Industries Inc.
 - i. Penn Ventilation Company, Inc.
 - j. Ruskin Company.
 - k. Vent Products Company, Inc.

3. Manufactured turning vanes
 - a. Ductmate Industries, Inc.
 - b. Duro Dyne Corp.
 - c. METALAIRE, Inc.
 - d. Ward Industries, Inc.

4. Duct-mounting access doors – rectangular
 - a. American Warming and Ventilating.
 - b. CESCO Products.
 - c. Ductmate Industries, Inc.
 - d. Flexmaster U.S.A., Inc.
 - e. Greenheck.
 - f. McGill AirFlow Corporation.
 - g. Nailor Industries Inc.
 - h. Ventfabrics, Inc.
 - i. Ward Industries, Inc.

5. Duct-mounting access doors – round
 - a. Ductmate Industries, Inc.
 - b. Flexmaster U.S.A., Inc.

6. Pressure-relief access door
 - a. American Warming and Ventilating.
 - b. CESCO Products.
 - c. Ductmate Industries, Inc.
 - d. Greenheck.
 - e. KEES, Inc.
 - f. McGill AirFlow Corporation.
 - g. Nexus PDQ.

7. Flexible connectors
 - a. Ductmate Industries, Inc.
 - b. Duro Dyne Corp.
 - c. Ventfabrics, Inc.
 - d. Ward Industries, Inc.

8. Flexible ducts
 - a. Flexmaster U.S.A., Inc.
 - b. Hart & Cooley, Inc.
 - c. McGill AirFlow Corporation.

2.2 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 (Z180) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts, compatible materials for aluminum and stainless steel ducts.
- D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less, 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 VOLUME DAMPERS

- A. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
 - 1. Pressure Classes of 3-Inch wg (750 Pa) or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
- B. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
 - 1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch (1.62 mm) thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
 - 2. Roll-Formed Steel Blades: 0.064-inch- (1.62-mm-) thick, galvanized sheet steel.
 - 3. Aluminum Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
 - 4. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
 - 5. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
 - 6. Blade Axles: Galvanized steel.
 - 7. Bearings: Molded synthetic.
 - 8. Tie Bars and Brackets: Galvanized steel.
- C. Jackshaft: 1-inch- (25-mm-) diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 - 1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.
- D. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon-locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.4 MOTORIZED CONTROL DAMPERS

- A. General Description: AMCA-rated, opposed-blade design; minimum of 0.1084-inch- (2.8-mm-) thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635-inch- (1.61-mm-) thick, galvanized-steel damper blades with maximum blade width of 8 inches (203 mm).
1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
 2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
 3. Provide closed-cell neoprene edging.

2.5 TURNING VANES

- A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.
- B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- (38-mm-) wide, double-vane, curved blades of galvanized sheet steel set 3/4 inch (19 mm) o.c.; support with bars perpendicular to blades set 2 inches (50 mm) o.c.; and **set one vane into each tab on vane runners** before duct mounting.

2.6 DUCT-MOUNTING ACCESS DOORS

- A. General Description: Fabricate doors airtight and suitable for duct pressure class.
- B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 2. Provide number of hinges and locks as follows:
 - a. Less Than 12 Inches (300 mm) Square: Secure with two sash locks.
 - b. Up to 18 Inches (450 mm) Square: Two hinges and two sash locks.
 - c. Up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles.
 - d. Sizes 24 by 48 Inches (600 by 1200 mm) and Larger: One additional hinge.
- C. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.
- D. Insulation: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.7 FLEXIBLE CONNECTORS

- 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 3-1/2 inches (89 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Select metal compatible with ducts.
- C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26-oz./sq. yd. (880 g/sq. m).
 - 2. Tensile Strength: 480 lab/inch (84 N/mm) in the warp and 360 lab/inch (63 N/mm) in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

2.8 FLEXIBLE DUCTS

- A. Noninsulated-Duct Connectors: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire.
 - 1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg 250 Pa negative.
 - 2. Maximum Air Velocity: 4000 fpm (20.3 m/s).
 - 3. Temperature Range: Minus 20 to plus 210 deg F (Minus 28 to plus 99 deg C).
- B. Insulated-Duct Connectors: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor barrier film.
 - 1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 - 2. Maximum Air Velocity: 4000 fpm (20.3 m/s).
 - 3. Temperature Range: Minus 20 to plus 210 deg F (Minus 28 to plus 99 deg C).
- C. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches (75 to 450 mm) to suit duct size.

2.9 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.
- B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.
- D. Provide test holes at fan inlets and outlets and elsewhere as indicated.
- E. 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 and equipment.
- F. Install the following sizes for duct-mounting, rectangular access doors:
 - 1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
 - 2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
 - 3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
 - 4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
 - 5. Body Access: 25 by 14 inches (635 by 355 mm).
 - 6. Body Plus Ladder Access: 25 by 17 inches (635 by 430 mm).
- G. Install the following sizes for duct-mounting, round access doors:
 - 1. One-Hand or Inspection Access: 8 inches (200 mm) in diameter.
 - 2. Two-Hand Access: 10 inches (250 mm) in diameter.
 - 3. Head and Hand Access: 12 inches (300 mm) in diameter.
 - 4. Head and Shoulders Access: 18 inches (460 mm) in diameter.
 - 5. Body Access: 24 inches (600 mm) in diameter.
- H. Install the following sizes for duct-mounting, pressure relief access doors:
 - 1. One-Hand or Inspection Access: 7 inches (175 mm) in diameter.
 - 2. Two-Hand Access: 10 inches (250 mm) in diameter.
 - 3. Head and Hand Access: 13 inches (330 mm) in diameter.
 - 4. Head and Shoulders Access: 19 inches (480 mm) in diameter.
- I. Label access doors according to Division 15 Section "Mechanical Identification."

- J. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
- K. For fans developing static pressures of 5-inch wg (1250 Pa) and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- L. Do not use flexible ducts to change directions.
- M. Connect diffusers to low pressure ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.
- N. Connect flexible ducts to metal ducts with draw bands.
- O. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 ADJUSTING

- A. Adjust duct accessories for proper settings.
- B. Final positioning of manual-volume dampers is specified in Division 15, Section 15950 "Testing, Adjusting, and Balancing."

END OF SECTION

SECTION 15838

POWER VENTILATORS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.
- D. The requirements of Section 15071, "Mechanical Vibration and Seismic Controls" apply to the installation of equipment defined by this section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Ceiling-mounting ventilators.
 - 2. Propeller fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

- A. Product Data: Include rated capacities, 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 gages and finishes, including color charts.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, and method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
 2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 3. Roof framing and support members relative to duct penetrations.
 4. Ceiling suspension assembly members.
 5. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- C. Maintenance Data: For power ventilators to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- D. UL Standard: Power ventilators shall comply with UL 705.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

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. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Ceiling-Mounting Ventilators:

- a. Ammerman Company, Inc./General Resource Corp.
- b. Breidert Air Products, Inc.
- c. Broan Mfg. Co., Inc.
- d. Carnes Company HVAC.
- e. Cook, Loren Company.
- f. Dayton Electric Manufacturing Co.
- g. Greenheck Fan Corp.
- h. ILG Industries, Inc./American Coolair Corp.
- i. JennFan; Div. of Breidert Air Products, Inc.
- j. NuTone Inc.
- k. Penn Ventilation Companies, Inc.

2. Propeller Fans:

- a. Acme Engineering & Mfg. Corp.
- b. Aerovent; a Twin City Fan Company.
- c. Bayley Fans, Lau Commercial Industrial Fans/Lau Industries.
- d. Breidert Air Products, Inc.
- e. Buffalo Forge Co./Howden Fan Co.
- f. Carnes Company HVAC.
- g. Chicago Blower Corp.
- h. Cook, Loren Company.
- i. Dayton Electric Manufacturing Co.
- j. Hartzell Fan, Inc.
- k. ILG Industries, Inc./American Coolair Corp.
- l. Industrial Air Division, Lau Commercial Industrial Fans/Lau Industries.
- m. JennFan; Div. of Breidert Air Products, Inc.
- n. New York Blower Company (The).
- o. NuTone Inc.
- p. Penn Ventilation Companies, Inc.
- q. Stanley Fans; Div. of Breidert Air Products, Inc.

2.2 CEILING-MOUNTING VENTILATORS

- A. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.

- B. Housing: Steel, lined with acoustical insulation.
- C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
- D. Grille: Plastic, louvered grille with flange on intake and thumbscrew attachment to fan housing.
- E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
- F. Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 percent to less than 50 percent.
 - 2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
 - 3. Isolation: Rubber-in-shear vibration isolators.

2.3 PROPELLER FANS

- A. Description: Belt-driven or direct-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.
- B. Housing: Galvanized steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.
- C. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.
- D. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - 1. Service Factor Based on Fan Motor: 1.4.
 - 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.
 - 4. Pulleys: Cast iron with split tapered bushing; dynamically balanced at factory.
 - 5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - 6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - 7. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
- E. Accessories:
 - 1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.

2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

2.4 MOTORS

- A. Comply with requirements in Division 15 Section "Motors."
- B. Enclosure Type: Guarded drip proof.

2.5 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- C. Support suspended units from structure using threaded steel rods and spring hangers. Vibration-control devices are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."
 1. In seismic zones, restrain support units.
- D. Install units with clearances for service and maintenance.
- E. Label units according to requirements specified in Division 15 Section "Mechanical Identification."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct

connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories."

- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment.
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Equipment Startup Checks:

- 1. Verify that shipping, blocking, and bracing are removed.
- 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
- 3. Verify that cleaning and adjusting are complete.
- 4. 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. 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.

B. Starting Procedures:

- 1. Energize motor and adjust fan to indicated rpm.
- 2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

G. Replace fan and motor pulleys as required to achieve design airflow.

H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Lubricate bearings.

3.5 CLEANING

- A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.
- B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

END OF SECTION

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SECTION 15840

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Shutoff single-duct air terminal units.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, and method of field assembly, components, and location and size of each field connection.
 - 1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
 - 1. Instructions for resetting minimum and maximum air volumes.
 - 2. Instructions for adjusting software set points.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units 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. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.5 COORDINATION

- A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Shutoff Single-Duct Air Terminal Units
 - a. Anemostat; a Mestek Company.
 - b. Carnes.
 - c. Environmental Technologies, Inc.; Enviro-Air Div.
 - d. Krueger.
 - e. METALAIRE, Inc.; Metal Industries Inc.
 - f. Price Industries.
 - g. Titus.
 - h. Trane Co. (The); Worldwide Applied Systems Group.

2.2 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

- A. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.
- B. Casing: 0.034-inch (0.85-mm) steel.

1. Casing Lining: 1-inch- (25-mm-) thick, coated, fibrous-glass duct liner complying with ASTM C 1071, secured with adhesive. Cover liner with nonporous foil and perforated metal.
 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 3. Air Outlet: S-slip and drive connections.
 4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance, with airtight gasket.
- C. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.
 2. Damper Position: Normally open.
- E. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig (1380 kPa); and factory installed.
- F. DDC Controls: Single-package unitary controller and actuator specified in Division 15 Section "HVAC Instrumentation and Controls."
- 2.3 SOURCE QUALITY CONTROL
- A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.
 - B. Verification of Performance: Rate air terminal units according to ARI 880.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to air terminal units to allow service and maintenance.

- C. Hot-Water Piping: In addition to requirements in Division 15 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
- D. Connect ducts to air terminal units according to Division 15; Section 15815 "Metal Ducts."
- E. Connect wiring according to Division 16 Section "Conductors and Cables."
- F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

END OF SECTION

SECTION 15855

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.
- B. Related Sections include the following:
 - 1. Division 10, Section 10200 "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
 - 2. Division 15, Section 15820 "Duct Accessories" for fire dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

- A. Product Data: For each product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Grilles and registers – adjustable bar

- a. Anemostat; a Mestek Company.
 - b. Carnes.
 - c. Hart & Cooley, Inc.; Hart & Cooley Div.
 - d. Krueger.
 - e. METALAIRE, Inc.; Metal Industries Inc.
 - f. Price Industries.
 - g. Titus.
 - h. Tuttle & Bailey.
2. Grilles and registers – fixed face
- a. Anemostat; a Mestek Company.
 - b. Carnes.
 - c. Hart & Cooley, Inc.; Hart & Cooley Div.
 - d. Krueger.
 - e. Price Industries.
 - f. Titus.
 - g. Tuttle & Bailey.
3. Rectangular and square ceiling diffusers
- a. Anemostat; a Mestek Company.
 - b. Carnes.
 - c. Hart & Cooley, Inc.; Hart & Cooley Div.
 - d. Krueger.
 - e. METALAIRE, Inc.; Metal Industries Inc.
 - f. Price Industries.
 - g. Titus.
 - h. Tuttle & Bailey.

2.2 GRILLES AND REGISTERS

A. Adjustable Bar Grille or Register:

1. Material: Steel or Aluminum.
2. Finish: Baked enamel, white.
3. Face Blade Arrangement: Adjustable horizontal and adjustable vertical 3/4 inch (19 mm) apart.
4. Rear Blade Arrangement: Adjustable vertical spaced 3/4 inch (19 mm) apart.
5. Frame: 1-1/4 inches (32 mm) wide.
6. Mounting: Countersunk screw or lay in.
7. Damper Type: Adjustable opposed-blade assembly.
8. Accessories: Front-blade gang operator.

B. Fixed Face Grille or Register:

1. Material: Steel or Aluminum.
2. Finish: Baked enamel, white.
3. Face Arrangement: 1/2-by-1/2-by-1/2-inch (13-by-13-by-13-mm) grid core.
4. Frame: 1 inch (25 mm) wide.
5. Mounting: Lay in.

2.3 CEILING DIFFUSER OUTLETS

- A. Rectangular and Square Ceiling Diffusers:
1. Material: Steel or Aluminum.
 2. Finish: Baked enamel, white.
 3. Face Size: 24 by 24 inches (600 by 600 mm).
 4. Face Style: Plaque.
 5. Mounting: T-bar.
 6. Pattern: Adjustable.
 7. Dampers: Radial opposed blade.
 8. Accessories:
 - a. Sectorizing baffles.

2.4 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 15900

HVAC INSTRUMENTATION AND CONTROLS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

1.3 DEFINITIONS

- A. DDC: Direct-digital controls.
- B. LAN: Local area network.
- C. MS/TP: Master-slave/token-passing.

1.4 SYSTEM DESCRIPTION

- A. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.
- B. Control system consists of sensors; indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multi-user, multitasking environment on token-passing network and programmed to control mechanical systems.

1.5 SEQUENCE OF OPERATION

- A. Sequence of Operation: All sequences of operation are contained on the drawings.

1.6 SUBMITTALS

- A. **Product Data:** Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
 - 1. Each control device labeled with setting or adjustable range of control.

- B. **Shop Drawings:** Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, and method of field assembly, components, and location and size of each field connection.
 - 1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
 - 2. **Wiring Diagrams:** Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
 - 3. Details of control panel faces, including controls, instruments, and labeling.
 - 4. Written description of sequence of operation.
 - 5. Schedule of dampers including size, leakage, and flow characteristics.
 - 6. Schedule of valves including leakage and flow characteristics.
 - 7. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
 - 8. Listing of connected data points, including connected control unit and input device.
 - 9. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
 - 10. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

- C. **Software and Firmware Operational Documentation:** Include the following:
 - 1. Software operating and upgrade manuals.
 - 2. **Program Software Backup:** On a magnetic media or compact disc, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.
 - 5. Software license required by and installed for DDC workstations and control systems.

- D. **Software Upgrade Kit:** For Owner to use in modifying software to suit future power system revisions or monitoring and control revisions.

- E. **Field Test Reports:** Indicate and interpret test results for compliance with performance requirements.

- F. **Maintenance Data:** For systems to include in maintenance manuals specified in Division 1. Include the following:
 - 1. Interconnection wiring diagrams with identified and numbered system components and devices.
 - 2. Keyboard illustrations and step-by-step procedures indexed for each operator function.
 - 3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

4. Calibration records and list of set points.

G. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.

1.7 COORDINATION

A. Coordinate location of thermostats, and other exposed control sensors with plans and room details before installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Control Systems Components:

- a. Honeywell, Inc.; Home & Building Control.
- b. Johnson Controls, Inc.; Controls Group.
- c. Siemens Controls, Inc.
- d. Trident Controls, Inc.
- e. Delta Controls
- f. Alerton Controls
- g. Siebe Barber-Coleman
- h. Andover Controls
- i. Trane

2. Electric, Electronic, and DDC Systems:

- a. Honeywell, Inc.; Home & Building Control.
- b. Johnson Controls, Inc.; Controls Group.
- c. Siemens Controls, Inc.
- d. Trident Controls, Inc.
- e. Delta Controls
- f. Alerton Controls
- g. Siebe Barber-Coleman
- h. Andover Controls
- i. Trane

2.2 DDC EQUIPMENT

A. Operator Station: Microcomputer station with printer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that conditioned power supply is available to control units and operator workstation.
- B. Verify that duct-, pipe-, and equipment-mounted devices and wiring are installed before proceeding with installation.

3.2 INSTALLATION

- A. Install equipment level and plumb.
- B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- C. Connect and configure/reconfigure equipment and software to achieve sequence of operation specified.
- D. Verify location of thermostats, and other exposed control sensors with plans and room details before installation. Locate all 48 inches (1219 mm) above the floor.
 - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- E. Install guards on thermostats in the following locations:
 - 1. Entrances.
 - 2. Public areas.
 - 3. Where indicated.
- F. Install automatic dampers according to Division 15 Section "Duct Accessories."
- G. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- H. Install labels and nameplates to identify control components according to Division 15 Section "Basic Mechanical Materials and Methods."
- I. Install labels and nameplates to identify control components according to Division 15 Section "Mechanical Identification."
- J. Install hydronic instrument wells, valves, and other accessories according to Division 15 Section "Hydronic Piping."
- K. Install refrigerant instrument wells, valves, and other accessories according to Division 15 Section "Refrigerant Piping."
- L. Install duct volume-control dampers according to Division 15 Sections specifying air ducts.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to Division 16 Section "Raceways and Boxes."
- B. Install building wire and cable according to Division 16 Section "Conductors and Cables."
- C. Install signal and communication cable according to Division 16 Section "Control/Signal Transmission Media."
 - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Install exposed cable in raceway.
 - 3. Install concealed cable in raceway.
 - 4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
- D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Install piping adjacent to machine to allow service and maintenance.
- B. Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

- 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. Operational Test: After electrical circuitry has been energized, 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, and retest.

3. Calibration test electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
- B. Engage a factory-authorized service representative to perform startup service.
- C. Replace damaged or malfunctioning controls and equipment.
 1. Start, test, and adjust control systems.
 2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
 3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.
- D. Verify DDC as follows:
 1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.
 2. Verify operation of operator workstation.
 3. Verify local control units including self-diagnostics.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain control systems and components.
 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
 2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs. Include a minimum of 40 hours' dedicated instructor time on-site.
 3. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
 4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.7 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

END OF SECTION

SECTION 15950

TESTING, ADJUSTING, AND BALANCING

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes TAB to produce design objectives for the following:
 - 1. Air Systems:
 - a. Variable air volume air systems.
 - b. Exhaust systems.
 - 2. Hydronic Piping Systems:
 - a. Variable-flow systems.
 - 3. HVAC equipment quantitative-performance settings.
 - 4. Verifying that automatic control devices are functioning properly.
 - 5. Reporting results of activities and procedures specified in this Section.

1.3 DEFINITIONS

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.
- C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

- D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- E. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- F. Report Forms: Test data sheets for recording test data in logical order.
- G. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
- H. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
- I. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- J. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- K. TAB: Testing, adjusting, and balancing.
- L. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- M. Test: A procedure to determine quantitative performance of systems or equipment.
- N. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 SUBMITTALS

- A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.
- D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- E. Sample Report Forms: Submit two sets of sample TAB report forms.
- F. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.
 - 1. Agenda Items: Include at least the following:
 - a. Submittal distribution requirements.
 - b. The Contract Documents examination report.
 - c. TAB plan.
 - d. Work schedule and Project-site access requirements.
 - e. Coordination and cooperation of trades and subcontractors.
 - f. Coordination of documentation and communication flow.
- B. TAB Report Forms: Use standard forms from TAB firm's forms approved by Architect.
- C. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
 - 1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.6 PROJECT CONDITIONS

- A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 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 TAB activities.
- B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.8 WARRANTY

- A. Guarantee shall include the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
 1. Contract Documents are defined in the General and Supplementary Conditions of 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 1 Section "Project Record Documents."
- D. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Compare this data with the design data and installed conditions.
- E. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual 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 that 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 HVAC equipment to ensure that 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 to verify that they are accessible and their controls are connected and functioning.
- K. Examine strainers for clean screens and proper perforations.
- L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- M. Examine system pumps to ensure absence of entrained air in the suction piping.
- N. Examine equipment for installation and for properly operating safety interlocks and controls.
- O. Examine automatic temperature system components to verify the following:
 - 1. The intended controller operates dampers, valves, and other controlled devices.
 - 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 multizone units, mixing boxes, and variable-air-volume terminals.
 - 4. Automatic modulating and shutoff valves, including two-way 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 indicated values.
 - 9. Interlocked systems are operating.
 - 10. Changeover from heating to cooling mode occurs according to indicated values.
- P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:
 - 1. Permanent electrical power wiring is complete.
 - 2. Hydronic systems are filled, clean, and free of air.
 - 3. Automatic temperature-control systems are operational.
 - 4. Equipment and duct access doors are securely closed.
 - 5. Balance dampers are open.
 - 6. Isolating and balancing valves are open and control valves are operational.
 - 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in this Section.
- B. 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 insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- D. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- F. Verify that motor starters are equipped with properly sized thermal protection.
- G. Check dampers for proper position to achieve desired airflow path.
- H. Check for airflow blockages.
- I. Check condensate drains for proper connections and functioning.
- J. Check for proper sealing of air-handling unit components.
- K. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance systems similar to constant-volume air systems.
 2. Set terminal units and supply fan at full-airflow condition.
 3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 4. Readjust fan airflow for final maximum readings.
 5. Measure operating static pressure at the sensor that controls the supply fan, if one is installed, and verify operation of the static-pressure controller.
 6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
 7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
 8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
1. Open all manual valves for maximum flow.
 2. Check flow-control valves for specified sequence of operation and set at indicated flow.
 3. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
 4. Set system controls so automatic valves are wide open to heat exchangers.
 5. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.7 PROCEDURES FOR HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
 4. Report flow rates that are not within plus or minus 5 percent of design.
- B. Set calibrated balancing valves, if installed, at calculated presetting.
- C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
1. Determine the balancing station with the highest percentage over indicated flow.
 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
 3. Record settings and mark balancing devices.
- F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.8 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer, model, and serial numbers.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Efficiency rating.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter thermal-protection-element rating.

- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.9 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

3.10 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Water Coils: Measure the following data for each coil:
 - 1. Entering- and leaving-water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.
 - 4. Dry-bulb temperature of entering and leaving air.
 - 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 - 6. Airflow.
 - 7. Air pressure drop.
- B. Refrigerant Coils: Measure the following data for each coil:
 - 1. Dry-bulb temperature of entering and leaving air.
 - 2. Wet-bulb temperature of entering and leaving air.
 - 3. Airflow.
 - 4. Air pressure drop.
 - 5. Refrigerant suction pressure and temperature.

3.11 PROCEDURES FOR TEMPERATURE MEASUREMENTS

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
- C. Measure outside-air, wet- and dry-bulb temperatures.

3.12 TEMPERATURE-CONTROL VERIFICATION

- A. Verify that controllers are calibrated and commissioned.

- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- C. Record controller settings and note variances between set points and actual measurements.
- D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
- E. Check free travel and proper operation of control devices such as damper and valve operators.
- F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
- G. Check the interaction of electrically operated switch transducers.
- H. Check the interaction of interlock and lockout systems.
- I. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or ungrounded power supply.
- J. Note operation of electric actuators using spring return for proper fail-safe operations.

3.13 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
 - 2. Air Outlets and Inlets: 0 to minus 10 percent.
 - 3. Heating-Water Flow Rate: 0 to minus 10 percent.

3.14 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.15 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 - 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.
- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
 - 1. Title page.
 - 2. Name and address of TAB firm.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of TAB firm who certifies the report.
 - 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 - 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 - 12. Nomenclature sheets for each item of equipment.
 - 13. Data for terminal units, including manufacturer, type size, and fittings.
 - 14. Notes to explain why certain final data in the body of reports varies from indicated values.
 - 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Other system operating conditions that affect performance.
- E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
 2. Water flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data: Include the following:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches (mm), and bore.
 - i. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
 - j. Number of belts, make, and size.
 - k. Number of filters, type, and size.
 2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in CFM (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Filter static pressure differential in inches wg (Pa).
 - f. Cooling coil static-pressure differential in inches wg (Pa).
 - g. Heating coil static-pressure differential in inches wg (Pa).
 - h. Outside airflow in CFM (L/s).
 - i. Return airflow in CFM (L/s).
 - j. Outside-air damper position.
 - k. Return-air damper position.
- G. Apparatus-Coil Test Reports:
1. Coil Data:

- a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in fins per inch (mm) o.c.
 - f. Make and model number.
 - g. Face area in sq. ft. (sq. m).
 - h. Tube size in NPS (DN).
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
- a. Airflow rate in CFM (L/s).
 - b. Average face velocity in fpm (m/s).
 - c. Air pressure drop in inches wg (Pa).
 - d. Outside-air, wet- and dry-bulb temperatures in deg F (deg C).
 - e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
 - f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
 - h. Water flow rate in gpm (L/s).
 - i. Water pressure differential in feet of head or psig (kPa).
 - j. Entering-water temperature in deg F (deg C).
 - k. Leaving-water temperature in deg F (deg C).
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig (kPa).
 - n. Refrigerant suction temperature in deg F (deg C).

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches (mm), and bore.
 - h. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
 - g. Number of belts, make, and size.

3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in CFM (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Suction static pressure in inches wg (Pa).

- I. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 1. Report Data:
 - a. System and air-handling unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F (deg C).
 - d. Duct static pressure in inches wg (Pa).
 - e. Duct size in inches (mm).
 - f. Duct area in sq. ft. (sq. m).
 - g. Indicated airflow rate in CFM (L/s).
 - h. Indicated velocity in fpm (m/s).
 - i. Actual airflow rate in CFM (L/s).
 - j. Actual average velocity in fpm (m/s).
 - k. Barometric pressure in psig (Pa).

- J. Air-Terminal-Device Reports:
 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Test apparatus used.
 - d. Area served.
 - e. Air-terminal-device make.
 - f. Air-terminal-device number from system diagram.
 - g. Air-terminal-device type and model number.
 - h. Air-terminal-device size.
 - i. Air-terminal-device effective area in sq. ft. (sq. m).

 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in CFM (L/s).
 - b. Air velocity in fpm (m/s).
 - c. Preliminary airflow rate as needed in CFM (L/s).
 - d. Preliminary velocity as needed in fpm (m/s).
 - e. Final airflow rate in CFM (L/s).
 - f. Final velocity in fpm (m/s).
 - g. Space temperature in deg F (deg C).

- K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in CFM (L/s).
 - b. Entering-water temperature in deg F (deg C).
 - c. Leaving-water temperature in deg F (deg C).
 - d. Water pressure drop in feet of head or psig (kPa).
 - e. Entering-air temperature in deg F (deg C).
 - f. Leaving-air temperature in deg F (deg C).
- L. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Unit make and model number.
 - d. Compressor make.
 - e. Compressor model and serial numbers.
 - f. Refrigerant weight in lb (kg).
 - g. Low ambient temperature cutoff in deg F (deg C).
 2. Test Data (Indicated and Actual Values):
 - a. Inlet-duct static pressure in inches wg (Pa).
 - b. Outlet-duct static pressure in inches wg (Pa).
 - c. Entering-air, dry-bulb temperature in deg F (deg C).
 - d. Leaving-air, dry-bulb temperature in deg F (deg C).
 - e. Condenser entering-water temperature in deg F (deg C).
 - f. Condenser leaving-water temperature in deg F (deg C).
 - g. Condenser-water temperature differential in deg F (deg C).
 - h. Condenser entering-water pressure in feet of head or psig (kPa).
 - i. Condenser leaving-water pressure in feet of head or psig (kPa).
 - j. Condenser-water pressure differential in feet of head or psig (kPa).
 - k. Control settings.
 - l. Unloader set points.
 - m. Low-pressure-cutout set point in psig (kPa).
 - n. High-pressure-cutout set point in psig (kPa).
 - o. Suction pressure in psig (kPa).
 - p. Suction temperature in deg F (deg C).
 - q. Condenser refrigerant pressure in psig (kPa).
 - r. Condenser refrigerant temperature in deg F (deg C).

- s. Oil pressure in psig (kPa).
- t. Oil temperature in deg F (deg C).
- u. Voltage at each connection.
- v. Amperage for each phase.
- w. Kilowatt input.
- x. Crankcase heater kilowatt.
- y. Number of fans.
- z. Condenser fan rpm.
- aa. Condenser fan airflow rate in CFM (L/s).
- bb. Condenser fan motor make, frame size, rpm, and horsepower.
- cc. Condenser fan motor voltage at each connection.
- dd. Condenser fan motor amperage for each phase.

M. Instrument Calibration Reports:

1. Report Data:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration.

3.16 INSPECTIONS

A. Initial Inspection:

- 1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
- 2. Randomly check the following for each system:
 - a. Measure airflow of at least 10 percent of air outlets.
 - b. Measure water flow of at least 5 percent of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Measure sound levels at two locations.
 - e. Verify that balancing devices are marked with final balance position.
 - f. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

- 1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
- 2. TAB firm test and balance engineer shall conduct the inspection in the presence of Architect.
- 3. Architect shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements

recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.

4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.17 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION

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SECTION 16010

GENERAL REQUIREMENTS FOR ELECTRICAL WORK

PART 1- GENERAL

1.1 REFERENCES

- A. Conditions of the Contract, Specifications, Change Orders, Addenda, Drawings and Division 1 General Requirements, apply to work of this section. Where paragraphs of this section conflict with similar paragraphs of Division 1, requirements of this section shall prevail.
- B. As used in this section, "provide" means "furnish and install", "furnish" means "to purchase and deliver to the project site complete with every necessary appurtenance and support and to store in a secure area in accordance with manufacturers instructions", and "install" means "to unload at the delivery point at the site or retrieve from storage, move to point of installation and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project".

1.2 EXAMINATION OF SITE

- A. Before submitting a bid, the Electrical Subcontractor shall visit and carefully examine site to identify existing conditions and difficulties that may affect the work of this Section. No extra payment will be allowed for additional work caused by unfamiliarity with site conditions.
- B. Before starting work in a particular area of the project, the Electrical Subcontractor shall examine the conditions under which work must be performed including preparatory work performed under other Sections of the Contract, or by the Owner and report conditions which might adversely affect the work in writing to the Architect. Do not proceed with work until defects have been corrected and conditions are satisfactory. Commencement of work shall be construed as complete acceptance of existing conditions and preparatory work.

1.3 SCOPE

- A. The work to be accomplished under these specifications includes providing all labor, materials, equipment, consumable items, supervision, administrative tasks, tests and documentation required to install complete and fully operational electrical systems as described herein and shown on the Drawings. The Electrical Subcontractor shall completely coordinate the work of this section with the work of other trades.
- B. The Electrical Subcontractor shall file plans, obtain permits and licenses, pay fees and obtain necessary inspections and approvals from authorities that have jurisdiction, as required to perform work in accordance with all legal requirements. The Electrical

Subcontractor shall pay utility backcharges and excess costs and perform work in accordance with utility company requirements.

- C. The Work shall be complete from point of service to each outlet or device with all accessory construction and materials required to make each item of equipment or system complete and ready for operation. The work shall include but not be limited to the following. The Electrical Subcontractor shall provide:
1. Secondary electrical service conduits and service entrance conductors. Arrange for and pay for any utility company work that may be requested by the utility.
 2. Meter enclosures and instrument cabinets for utility company revenue metering.
 3. Complete grounding system.
 4. Empty conduit from pole riser to the building for Telephone, CATV and Fire Alarm.
 5. Complete power and lighting distribution systems including service disconnect, distribution panels, panelboards, overcurrent devices, raceway, cable and wire.
 6. Branch circuits and devices for power and convenience receptacles.
 7. All motor wiring, safety disconnects, and motor starters unless integral with equipment.
 8. Complete interior lighting system including normal and emergency fixtures, exit signs, lamps, controls, trim and accessories.
 9. Complete exterior lighting system including building and site lighting fixtures, poles, controls, lamps and accessories.
 10. Complete fire alarm and detection system including master box, pull stations, heat detectors, area smoke detectors, duct smoke detectors, indicating appliances, remote annunciator, water flow and tamper switch wiring, auxiliary contacts for equipment interlocking, and other devices shown on the Drawings.
 11. Variable frequency drives.
 12. Empty conduits for voice/data outlets
 13. Empty conduit for CATV outlets.
 14. Control wiring not provided by Division 15000.
 15. All support material and hardware for raceway, cable tray and electrical equipment.
 16. Branch circuits to control panels and devices furnished under other sections.

17. Portable Generator and Manual Transfer Switch Panel Assembly.
 18. Termination of all cable and wire unless otherwise noted.
- D. Install the following items furnished by others:
1. Motors
 2. Control Panels
- E. Commissioning: The project will include commissioning of select power, lighting, and life safety systems. The Electrical Contractor shall support this efforts as required per Section 01352, "Commissioning Requirements."

1.4 RELATED WORK IN OTHER SECTIONS

- A. The following work is not included in this Section and shall be performed under other sections:
1. Commissioning, (see Division 1 Section, "Commissioning Requirements").
 2. Excavation and backfill.
 3. Concrete work, including concrete housekeeping pads and other pads and blocks for vibrating and rotating equipment.
 4. Cutting and patching of masonry, concrete, tile, and other parts of structure, with the exception of drilling for hangers and providing holes and openings in metal decks.
 5. Installation of access panels in ceilings and wall construction.
 6. Painting, except as specified herein.
 7. Temporary water, heat, gas and sanitary facilities for use during construction and testing.
 8. Outdoor air intake or exhaust louvers.
 9. Cathodic anti-corrosion protection for buried piping and tanks.
 10. Control wiring specifically indicated as part of Division 15.
- B. The Electrical Subcontractor shall identify locations of penetrations, excavations, structural supports, etc. required for the completion of the Work of this Section to the General Contractor in a timely manner.

1.5 CODES, STANDARDS, AND AUTHORITIES

- A. All work shall be performed strictly as required by rules, regulations, standards, codes, ordinances, and laws of local, state, and Federal governments, and other authorities that have lawful jurisdiction. Materials and equipment shall be manufactured, installed and tested as specified in latest editions of publications, standards, rulings, and determinations of:
1. Local and state building, plumbing, mechanical, electrical, fire and health department and public safety codes agencies.
 2. National Fire Protection Association (NFPA)
 3. Occupational Safety and Health Act (OSHA)
 4. Factory Mutual Association (FM)
 5. National Electrical Code (NEC)
 6. National Electrical Safety Code (NESC).
 7. The BOCA National Building Code.
- B. All materials and equipment shall be listed by Underwriters Laboratories (UL), and approved for intended service.
- C. When requirements cited in this Paragraph conflict with each other or with Contract Documents, the most stringent requirements shall govern conduct of work. The Architect may relax this requirement when such relaxation does not violate the ruling of authorities that have jurisdiction. Approval for such relaxation shall be obtained in writing.

1.6 WARRANTY

- A. Refer to Division 1 General Requirements for Warranty Requirements.

1.7 CONTRACT DRAWINGS

- A. Work to be performed under this section is shown on the electrical drawings listed in Division 1 General Requirements.
- B. The listing of electrical drawings does not limit responsibility of determining full extent of work required by contract documents. The Electrical Subcontractor shall refer to architectural, plumbing, HVAC, structural, and other drawings and other sections that indicate types of construction with which work of this section must be coordinated. The Electrical Subcontractor shall check with the General Contractor and other subcontractors to determine whether there will be any interference by such trades with the electrical work. If the Electrical Subcontractor fails to check with the General Contractor and subcontractors and the electrical work is later found to interfere with their work, then he

shall make necessary changes, without additional cost to the Owner, to eliminate such interference.

- C. Drawings are diagrammatic and indicate general arrangement of systems and work included in contract. information and components shown on riser diagrams or called for in the specifications but not shown on plans, and vice versa, shall apply and shall be provided as though required expressly by both. It is not intended to specify or to show every offset, fitting, or component; however, contract documents require components and materials whether or not indicated or specified as necessary to make electrical installation complete and operational.

1.8 DISCREPANCIES IN DOCUMENTS

- A. It shall be the responsibility of each bidder to examine the drawings and specifications carefully before submitting his bid, with particular attention to errors, omissions, conflicts with provisions of laws and codes imposed by authorities having jurisdiction, conflicts between portions of drawings, or between drawings and specifications, and ambiguous definition of the extent of coverage in the contract. Any such discrepancy discovered shall be brought to the immediate attention of the Architect for correction. Should any of the aforementioned errors, omissions, conflicts or ambiguities exist in either or both the drawings and specifications, the Electrical Subcontractor shall have the same explained and adjusted in writing before signing the contract or proceeding with work. Failure to notify the Architect in writing of such irregularities will cause the Architect's interpretation of the Contract Documents to be final. No additional compensation will be approved because of discrepancies thus resolved.
- B. The drawings and these specifications are intended to comply with all the above mentioned rules and regulations. If discrepancies occur, the Electrical Subcontractor shall immediately notify the Architect in writing of said discrepancies and apply for an interpretation and, unless an interpretation is offered in writing by the Architect prior to the execution of the contract, the applicable rules and regulations shall be complied with as a part of the contract.
- C. In case of difference between building codes, specifications, state laws, industry standards and the contract documents, the most stringent shall govern. Should the Electrical Subcontractor perform any work that does not comply with the requirements of the applicable building codes, state laws, and industry standards, he shall bear all costs arising in correcting these deficiencies.

1.9 EQUIPMENT AND MATERIALS

- A. All equipment and materials shall be new and of the quality specified. All materials shall be free from defects at the time of installation. Materials or equipment damaged in shipment or otherwise damaged during construction shall not be repaired at the jobsite, but shall be replaced with new materials.
- B. All equipment installed on this project shall have local representation, local factory authorized service and a local stock of repair parts.

- C. No equipment or material shall be installed in such a manner as to void a manufacturer's warranty. The Electrical Subcontractor shall notify the Architect of any discrepancies between the Contract Documents and manufacturer's recommendations prior to execution of the work.

1.10 RECORD DRAWINGS

- A. As work progresses, and for duration of the Contract, the Electrical Subcontractor shall maintain a complete and separate set of prints of Contract Drawings at job site at all times and record work completed and all changes from original Contract. Drawings shall clearly and accurately include work installed as a modification or added to the original design.
- B. At completion of work and prior to final request for payment, the Electrical Subcontractor shall submit a complete set of reproducible record drawings showing all systems as actually installed.

1.11 SHOP DRAWINGS

- A. After the Contract is awarded, but prior to proceeding with the Work, the Electrical Subcontractor shall obtain complete shop drawings, product data and samples from manufacturers, suppliers, vendors, and Subcontractors for all materials and equipment specified herein, and submit data and details of such materials and equipment for review by the Architect and Engineer. Prior to submission of the shop drawings, product data and samples to the Architect, the Electrical Subcontractor shall review and certify that the shop drawings, product data and samples are in compliance with the Contract Documents. Further, the Electrical Subcontractor shall check all materials and equipment after their arrival on the jobsite and verify their compliance with the Contract Documents. A minimum period of ten working days, exclusive of transmittal time will be required in the Engineer's office each time shop drawings, product data and/or samples are submitted or resubmitted for review. This time period shall be considered by the Electrical Subcontractor when scheduling his Work.
- B. The Electrical Subcontractor shall submit to the Architect four (4) copies of shop drawings. All copies shall be neatly bound in folders. Additional copies required for distribution shall be the responsibility of the Electrical Subcontractor after reviewed copies are returned to him with the Architect and Engineer's review comments and notes.
- C. Each shop drawing shall indicate in the lower right hand corner, and each product data brochure shall indicate on the front cover the following: Title of the sheet or brochure; name and location of the building; names of the Architect and Engineer, Contractor, Subcontractor, manufacturer, supplier, vendor; the date of submittal; and the date of each correction and revision. So far as is practical, each shop drawing, product data and/or samples shall bear a cross-reference note to the page or sheet number of the Drawings and/or Specifications showing the Work. Unless the above information is included, the submittal will be returned for resubmittal without review.
- D. The shop drawing submittal shall include all data necessary for interpretation as well as manufacturer's name and catalog number. Sizes, capacities, colors, etc., specified on the drawings shall be specifically noted or marked on the shop drawings.

- E. Submittals shall contain only information specific to systems, equipment and materials required by Contract Documents for this Project. Do not submit catalogs that describe products, models, options or accessories, other than those required, unless irrelevant information is marked out or unless relevant information is highlighted clearly. Marks on submittals, whether by Contractor, Subcontractor, manufacturer, etc., shall not be made in red ink. Red is reserved for review process.
- F. All specification sheets, drawings and diagrams shall be submitted within 30 days from the date of Electrical Subcontractor signs the Contract. The Architect and Engineer's review of such drawings shall not relieve the Subcontractor of responsibility for deviations from the Contract, Drawings or Specifications, unless he has in writing called the attention of the Architect to such deviations at the time of the submission. The Architect's review shall not relieve the Electrical Subcontractor from responsibility for errors or omissions in such drawings.
- G. If the Electrical Subcontractor proposes an item of equipment other than that specified or detailed on the drawings which requires any redesign of the wiring or any other part of the mechanical, electrical or architectural layout, the required changes shall be made at the expense of the trade furnishing the changed equipment at no cost to the Owner.
- H. Manufacturer's names are listed herein and on the drawings to establish a standard for quality and design. Where one manufacturer's name is mentioned, products of other manufacturers will be acceptable if, in the opinion of the Architect the substitute material is of quality equal to or better than that of the material specified. Where two or more manufacturer's names are specified, material shall be by one of the named manufacturers only.

1.12 BULLETINS, MANUALS, AND INSTRUCTIONS

- A. The Electrical Subcontractor shall obtain at time of purchase of equipment, three copies of operation, lubrication and maintenance manuals for all items and assemble literature in coordinated manuals with additional information describing combined operation of field assembled units, including as-built wiring diagrams. Manuals shall contain names and addresses of manufacturers and local representatives who stock or furnish repair parts for items or equipment. Divide manuals into two sections or books as follows:
 - 1. Directions for and sequence of operation of each item of electrical systems, e.g. emergency generator, sound system, fire alarm system, etc.
 - 2. Detailed maintenance and trouble shooting manuals containing data furnished by manufacturer for complete maintenance.
- B. Furnish three copies of manuals to the Architect for review and distribution to Owner. Deliver manuals no less than 30 days prior to acceptance of equipment to permit Owner's personnel to become familiar with equipment and operation prior to acceptance.
- C. Upon completion of installation or when Owner accepts portions of building and equipment for operational use, instruct the Owner's operating personnel in any and all parts of various systems. Such instructions shall cover period of control such as will take

mechanical equipment through complete cycle. Make adjustments under actual operating conditions.

1.13 TEMPORARY LIGHT AND POWER

- A. The Electrical Subcontractor shall furnish, install and remove the temporary electrical power and lighting systems and pay for all labor, materials, and equipment required therefore. All such temporary electrical work shall meet the requirements of the National Electrical Code, the local utility company, and OSHA.
- B. The Electrical Subcontractor shall make all necessary arrangements with the local utility company as to where the temporary electric service can be obtained from.
- C. The Electrical Subcontractor shall secure and pay for all required permits and back charges for work performed by others, and other expenses incidental to the installation of the temporary electric service.
- D. The Electrical Subcontractor shall provide a temporary service to the building as required to provide electric light and power while the building is under construction and until the permanent feeders have been installed, tested and accepted by the Owner. Install and maintain a feeder or feeders of sufficient capacity for the requirements of each floor.
- E. The temporary electric service shall be based on the following:
 - 1. Rooms or spaces under 250 sq. ft. - one (1) 100 watt lamp.
 - 2. Rooms or spaces over 250 sq. ft. and under 500 sq. ft. - two (2) 100 watt lamps.
 - 3. Rooms or spaces over 500 sq. ft. - one (1) 200 watt lamp per every 1,000 sq. ft. or fraction thereof.
 - 4. Sufficient wiring outlets and lamps shall be installed to insure proper lighting in stairwells, corridors, and passage areas.
 - 5. Temporary power, in addition to the lighting requirements, shall be provided throughout the building for electrically operated tools on a minimum of 0.5 watts per sq. ft. Motors up to and including one hp only shall be provided for.
 - 6. Outlets shall be located at convenient points so that extension cords of not over 50 ft. in length will reach all work requiring light or power.
- F. All necessary overhead pole lines, transformers, meters, cables, panelboards, switches, and accessories required by the temporary light and power installation shall be provided by the Electrical Subcontractor.
- G. The General Contractor shall pay the costs of all energy consumed by himself and by all of his subcontractors until final completion.
- H. The Electrical Subcontractor shall furnish all lamps, both initial and replacement, used for the temporary lighting system.

- I. The General Contractor and all subcontractors, individually, shall furnish all extension cords, portable lights and lamps therefore, sockets, motors, and accessories as required for their work.
- J. The General Contractor and all subcontractors shall reimburse the Electrical Subcontractor for the following:
 - 1. Any temporary wiring of a special nature, other than that specified above, required for their work.
 - 2. Any temporary wiring of construction offices and buildings used by them, other than the office of the General Contractor and the Clerk of the Works.
- K. All temporary wiring, service equipment, and accessories thereto shall be removed by the Electrical Subcontractor when directed by the General Contractor.
- L. All lamps installed in permanent lighting fixtures and used as temporary lights during the construction period, shall be removed and replaced with new lamps.

1.14 SPACE, EQUIPMENT ARRANGEMENT AND ACCESS

- A. The size of equipment shown on the drawings is based on the dimensions of a particular manufacturer. Where other manufacturers are acceptable, it is the responsibility of the Electrical Subcontractor to determine if the equipment he proposed to furnish will fit the space available. Shop drawings shall be prepared by the Subcontractor when required by the Architect or Owner to indicate a suitable arrangement.
- B. Locate all equipment which must be serviced, operated or maintained in fully accessible positions. Minor deviations from the drawings may be made to allow for better accessibility at no additional cost to the Owner, but changes shall not be made without review by the Architect.
- C. Minimum clearances in front of or around equipment shall conform to the latest applicable code requirements.

1.15 MARKING AND LABELING

- A. All panelboards, indoor transformers, cabinets and other specified equipment shall be labeled with engraved laminated plastic plates, minimum 3/4" high with 3/8" engraved letters. Punch tapes with mastic backings are not acceptable.
- B. All starters, disconnect switches and other specified equipment shall be marked with engraved laminated plastic plates, minimum 1/2" high with 1/4" engraved letters. Where individual switches or circuit breakers in power or distribution panelboards do not have cardholders, they shall be marked with 1/2" high labels.
- C. All empty conduits shall have labels tied to the pull string at each end of each empty conduit, marked as to identification of each end. Junction boxes with circuits provided for future use shall be labeled with appropriate circuit designation.

- D. Cardholders for panelboard shall be filled out with typewritten identification of each circuit, except that the word "spare" shall be written in soft pencil to identify all circuit breakers installed that are not used.

1.16 WIRING METHODS

- A. Unless otherwise noted all wiring shall be installed in raceway and installed as follows:
1. All service conductors shall be installed in rigid steel, rigid aluminum or intermediate metal conduit.
 2. All conduit installed outdoors, all risers between floors and conduit exposed to physical damage shall be rigid steel, rigid aluminum or intermediate metal conduit.
 3. Unless otherwise noted, all other power distribution wiring including feeders and branch circuits shall be installed in electrical metallic tubing (EMT). MC cable can be used for wiring of branch circuits where properly supported and neatly installed above ceiling areas and in wall spaces.
 4. All fire alarm system wiring shall be installed in EMT or red MC cable listed for this use and acceptable to the local fire and wiring inspector.
 5. Telephone and data conduits shall be EMT in wall spaces from work box to a location above the accessible ceiling. Conduits shall be a minimum of 1".
 6. CATV conduits shall be EMT in wall spaces from work box to location above the accessible ceiling. Conduits shall be a minimum of 3/4".
 7. Conduit installed in floor slabs shall be rigid nonmetallic conduit with rigid steel stubups.
 8. Site lighting branch circuits shall be direct buried rigid nonmetallic conduit.

END OF SECTION 16010

SECTION 16030

ELECTRICAL ACCEPTANCE TESTING

PART 1 - GENERAL

1.1 GENERAL

- A. Provisions of Section 16010, General Requirements for Electrical Work apply to the work of this Section.
- B. This Specification Section covers the field inspection, mechanical completeness, and electrical acceptance tests required for electrical apparatus, wire, cable and other miscellaneous equipment and material installed and wired by Contractor.
- C. The Contractor shall prepare written procedures for the performance of all testing. The procedures shall include an itemization of all equipment, devices, cable and material requiring field testing, setting, adjustment or calibration and shall describe the required set points. The procedures shall be submitted to the Engineer for review prior to the commencement of any testing.
- D. The Contractor shall maintain records for all tests and inspections, with complete data on all readings taken. Test results shall be recorded on standard test forms. All reports shall be dated and shall include the name of the person performing the test.

PART 2 - PRODUCTS

2.1 GENERAL

- A. The equipment to be tested under this Section is generally provided under other Specification Sections.

PART 3 - EXECUTION

3.1 EXECUTION

- A. Upon completion of the installation, the Contractor shall perform field tests on all equipment, materials and systems to insure that the entire installation is sound and that all circuits, including power, control, relaying, instrumentation and metering will function properly and as intended.
- B. The Contractor shall furnish and maintain all tools, instruments, materials, test equipment, test connections and personnel, including supervision and labor required for testing, setting and adjusting of all electrical equipment.
- C. All tests shall be performed with proper regard for the protection of equipment and the Contractor shall be responsible for adequate protection of all personnel during such tests.
- D. No equipment shall be installed, operated or tested in such a manner as to void the manufacturer's warranty or guarantee. Should any test values or procedures as indicated in this Specification exceed the values or overrule the procedures recommended by the manufacturer for the equipment

involved, the manufacturer's recommendation, shall take precedence.

- E. Prior to energizing or placing in service any electrical equipment, testing and checking shall be completed.
- F. The witnessing or waiving of witnessing of any test shall not relieve the Contractor of its guarantees for material, equipment and workmanship.
- G. The Contractor shall promptly advise the Engineer in writing concerning the failure of any equipment or material to pass the tests performed, or to properly function as intended, or to meet calibration accuracy required. After the defects have been corrected, the test(s) shall be repeated.

3.2 ROTATING EQUIPMENT

- A. All motors shall be subjected to a one minute megger test, resistance measured to ground with all phase leads tied together. Minimum insulation resistance values are as follows:

Equipment Rating (volts)	600 or less
Megger Rating (volts)	1000
Min Resistance (megohms)	10

If minimum resistance values are not obtained, the equipment shall be dried out as required, and the above test repeated.

- B. The following visual inspection shall be made on all motors:
 - 1. Check bearings for free rotation.
 - 2. Check all ventilation openings for blockages.
 - 3. Check bearing lubrication and correct as necessary.
 - 4. Check that frame is grounded.
 - 5. Check motor leads for proper connection and color coding.
- C. The Contractor shall check all motors for proper rotation by bumping motors. Coupled motors shall not be bumped. The Contractor shall correct motor connections as necessary.

3.3 WIRE AND CABLE

- A. Control and Instrument Wiring - Control and instrument field wiring shall be visually inspected and tested for continuity to insure that all field wiring is installed in accordance with Contract Drawings and/or equipment manufacturers drawings. Verify all field conductors are properly identified with wire numbers.
- B. Low Voltage Power Wiring - All 208V power wiring shall be subjected to one minute 1000V megger test. Minimum insulation resistance shall be 50 megohms. Megger tests shall be performed between each phase (A-B, B-C, and C-A) and three phases tie together to ground.

3.4 CALIBRATION

- A. The Contractor shall check, calibrate and operate all protective relays, timers, meters, instruments and devices furnished under this Division, in accordance with manufacturers recommendations. Equipment furnished under other Divisions will be calibrated by others.
- B. Ratios of current and potential instrument transformers shall be verified by test.

3.5 FUNCTIONAL TESTING

- A. Unless otherwise noted, the Contractor shall energize and operate all alarm and control circuits under simulated or actual system conditions to verify the correctness of wiring. All control circuits shall be checked in their entirety.
- B. Control wiring, circuits and devices furnished and installed by Division 15 will be tested by Division 15.

3.6 GROUNDING

- A. The Contractor shall measure the resistance to earth of the grounding system using the three terminal fall of potential method.

END OF SECTION 16030

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SECTION 16050

INSTALLATION OF ELECTRICAL EQUIPMENT

PART 1 - GENERAL

1.1 GENERAL

- A. The provisions of Section 16010 General Requirements for Electrical Work apply to the work of this section.
- B. Included in the work of this section is the assembly, installation and wiring of all parts, subassemblies and shipping sections of the electrical switchgear, panels, motor control centers, control panels, motors, disconnect switches, variable speed drives and similar equipment.
- C. Testing shall be performed in accordance with Section 16030 Electrical Acceptance Testing.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Equipment to be installed under this section is generally furnished under other specification sections.

PART 3 - EXECUTION

3.1 GENERAL

- A. All equipment shall be completely assembled, installed and connected and shall be fully prepared and made ready for operation. The Contractor may employ the use of any special tools furnished with the equipment specifically for installation purposes, but shall not use tools furnished with the equipment for maintenance purposes. The Contractor shall acquaint himself with and follow special instructions of the Manufacturer for the care, handling and installation of the equipment.
- B. After installation, all operating parts shall be inspected to insure correct mechanical operation.
- C. Internal wiring within any equipment which has been disconnected for shipping purposes shall be reconnected. Any wiring not installed by reason of shipping requirements shall also be installed. The Contractor may disconnect internal wiring as necessary for installation purposes, and shall reconnect all wiring so disconnected.
- D. After installation, all equipment shall be left in clean conditions. In particular, all insulators, bushings, insulating materials, and other parts which are depended upon for their insulating qualities shall be thoroughly cleaned.

- E. No overall painting of equipment will be required, but housing surfaces which have been soiled or marred shall be touched up or refinished with primer and color coat.
- F. Drilling, tapping, cutting, or welding of equipment required for mounting or for conduit and cable entrances to suit particular conditions of installation shall be considered as part of electrical equipment installation.
- G. All equipment shall be provided with engraved nameplates in accordance with Section 16010 and the drawings.

3.2 SUPPORTS

- A. The Contractor shall size and provide all supports necessary for the installation of the electrical equipment.
- B. Supports shall be designed for seismic forces in accordance with the 1996 BOCA National Building Code, Section 1610.]
- C. Channel framing shall be manufactured by Unistrut, Kindorf, B-Line or approved equal.
- D. In dry, non corrosive areas, channel framing shall be galvanized steel or aluminum and all nuts, bolts and hardware shall be carbon steel, cadmium plated or hot dipped galvanized.
- E. In outdoor, wet or damp areas channel framing shall be aluminum or 304 stainless steel and nuts, bolts and hardware shall be 304 stainless steel.
- F. In corrosive areas, channel framing shall be 316 stainless steel, PVC coated steel or PVC coated aluminum. Nuts, bolts and hardware shall be 316 stainless steel.
- G. Supports shall be sized with a minimum safety factor of four or 200 lbs. whichever is greater.
- H. Fastening to steel may be welded or bolted. Fastening to solid masonry or concrete shall be machine bolts with expansion shields. Fastening to hollow masonry shall be by toggle bolts.

3.3 WIRING

- A. All external connections to electrical equipment shall be completed by the Contractor. Wiring shall be neatly formed, trained and tied with nylon cable ties in all equipment.
- B. All power conductors shall be color coded. All control wiring shall be identified with sleeve type wire markers with wire numbers matching those on the manufacturers schematic and connection diagrams.
- C. All bus work shall be properly phased "A", "B", "C" left to right, front to back or top to bottom.

3.4 PANELBOARDS AND DISTRIBUTION PANELS

- A. The Contractor shall mount equipment at locations shown on the drawings, install all interiors, branch circuit protective devices, complete all external connections and install exterior trim.
- B. The panelboard circuit directory card shall be completed in accordance with Section 16010.

3.5 MOTOR SAFETY SWITCHES, LOCAL MOTOR STARTERS AND VARIABLE SPEED DRIVES

- A. Equipment shall be installed at locations shown on the drawings. The Contractor shall provide all support material and framing required for proper support.
- B. Enclosures installed on concrete surfaces or surfaces where condensation is likely to occur shall clear the mounting surface by at least 1/4 inch.
- C. Conduit shall be bottom entry to all enclosures installed outdoors or in wet or damp areas.

3.6 MOTORS

- A. Motors shall be set plumb and aligned with shafts or pulleys.
- B. Motor connections shall be made with compression lugs installed on the motor leads and the motor branch circuit conductors, bolted together.
- C. Motor connections shall be wrapped with varnished cambric tape, then insulated with Super 33 Scotch Vinyl electric tape or insulated with motor connection kits as manufactured by Raychem or 3M.

END OF SECTION 16050

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SECTION 16060

INSTALLATION OF WIRE AND CABLE

PART 1 - GENERAL

1.1 GENERAL

- A. The Provisions of Section 16010 General Requirements for Electrical Work apply to the Work of this Section.

1.2 CODES AND STANDARDS:

- A. Products shall comply with the following codes and standards and shall be UL-listed and labeled where applicable.

UL 486A Wire Connectors and Soldering Lugs for use with Copper Conductors.

UL 510 Electrical Insulating Tape

1.3 SUBMITTALS

- A. Manufacturers product data sheets

PART 2 - PRODUCTS

2.1 WIRE AND CABLE

- A. Wire and cable are specified in other Sections of Division 16000.

2.2 TERMINATIONS AND SPLICES

- A. Power Wiring:

1. Terminal lugs, connectors and splices shall be tin plated, high conductivity copper compression type. They shall have chamfered barrels and be permanently identified with conductor sizes.
2. Terminal lugs for conductors No. 3/0 AWG and larger shall be long barrel NEMA two-hole type.
3. Splices shall be long barrel butt type with a center stop in the splice barrel.
4. Hydraulic crimping tools with proper die sizes which require full closure before reopening shall be used.

- B. Lighting and branch circuits

1. Splices and taps in lighting and branch circuit wiring shall be 3M Hyflex connectors or equal.

- C. Metal clad cable connectors.

1. For non-jacketed metal clad cable in dry locations, cable terminations shall be O.Z. Gedney Type PK for use with galvanized steel armor or Type PK-A for use with aluminum armor. Cable terminations shall be provided with locknuts and bushings.
2. For jacketed metal clad cable, cable terminators shall be Thomas & Betts "SPIN-ON" [in non-hazardous areas and "SPIN-ON X" in Class 1 Division 2 areas.]

PART 3 - EXECUTION

3.1 GENERAL

- A. Conductors shall be carefully handled during installation to avoid damage of any kind. They shall be unreeled or uncoiled slowly in order to prevent damage to the insulation or sheath due to sudden bending. Repeated bending shall be avoided. Sharp kinks shall be avoided in unreeling, uncoiling and pulling.
- B. Suitable precautions shall be made to protect all installed wiring against damage due to construction activities.

3.2 PREPARATION OF RACEWAYS

- A. Raceways shall be substantially completed before any wiring is installed in them. Before any wiring is pulled into a conduit, the conduit shall be cleaned and tested for obstructions and cleared of foreign material that may be found.

3.3 PULLING INTO RACEWAYS

- A. All possible care shall be taken in pulling of wiring into conduits or other raceways. The cable reels or coils shall be set up in such a way that the conductor may be trained into the raceway as directly as possible with a minimum number of changes of direction or amount of bending. Where several cables are contained in one conduit, all such cables shall be pulled in together.
- B. The use of pulling lubricants shall be restricted to non hardening type, approved by UL and the cable manufacturer.
- C. Maximum allowable pull tension as specified by the cable manufacturer shall not be exceeded. Cables shall not be bent or pulled around sheaves less than the minimum radius recommended by the manufacturer.

3.4 SPLICES AND TERMINATIONS

- A. All power and control wiring shall be continuous and shall not be spliced unless otherwise indicated on the Drawings.
- B. Bolts, nuts and hardware used for terminations shall be silicone bronze. All terminations shall be properly torqued and provided with Belleville washers.
- C. Where terminations are made on insulated buses, the terminations shall be insulated using the proper tape(s) and fillers for the voltage level of the cable.

- D. Connections in motor terminal boxes shall be made by installing compression type lugs on the motor branch circuit conductors and the motor leads and bolting the lugs together then insulating with motor lead connection kits, Raychem, 3M or equal.
- E. Control wiring terminated on terminal blocks provided with saddle clamps does not require terminal lugs. Where screw or stud type terminal blocks are provided, control wiring shall be terminated with insulated, crimp type locking forks, Thomas & Betts STA-KON or approved equal.

3.5 IDENTIFICATION

- A. All power wiring conductors shall be color coded as follows:

<u>Phase</u>	<u>208Y/120V</u>
Phase A	Black
Phase B	Red
Phase C	Blue
Neutral	White
Ground	Green

- B. Each cable shall be permanently identified with cable numbers as indicated on the Drawings. Tags shall be provided at each end and in pull and splice boxes.
- C. Each control conductor shall be identified with a preprinted, sleeve type wire marker. The wire numbers shall match those shown on the Drawings or on manufacturer's schematic and connection diagrams.

3.6 TESTING

- A. Wire and cable shall be tested in accordance with Section 16030 "Electrical Acceptance Testing".

END OF SECTION 16060

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SECTION 16070

GROUNDING

PART 1 - GENERAL

1.1 GENERAL

- A. The provisions of Section 16010, General Requirements for Electrical Work apply to the Work of this Section.
- B. The Contractor shall provide a complete grounding system including grounding electrodes, electrode conductors, bonding jumpers, equipment grounding conductors, connections and other materials as may be required.

1.2 CODES AND STANDARDS:

- A. Products shall comply with the following codes and standards and shall be UL listed and labeled.
 - NFPA 70 National Electrical Code
 - UL 467 Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1 GROUND RODS

- A. Ground rods shall be 3/4 inch copper clad steel furnished in 10 foot lengths.

2.2 CONDUCTORS

- A. Bare grounding conductors shall be soft drawn stranded copper, sized in accordance with NEC Article 250 unless otherwise noted on the Drawings.
- B. Insulated grounding conductors shall be stranded copper with Type TW, THW or THHN/THWN insulation colored green.

2.3 CONNECTIONS

- A. Welded connections shall be exothermic reaction type, Cadweld or approved equal. The Contractor shall provide all molds, crucibles, weld metal and necessary materials to complete all connections.
- B. Lugs shall be long barrel, two hole compression type for No. 3/0 AWG wire and larger and short barrel, one hole compression type for grounding conductors No. 2/0 AWG and smaller.

PART 3 - EXECUTION

3.1 GROUNDING ELECTRODE SYSTEM

- A. Grounding electrodes as shown on the Drawings and as required by code shall be provided. All electrodes shall be bonded together to form the grounding electrode system.

- B. Ground rods shall be driven vertically with the upper end of the rod not less than 2-1/2 feet below finished grade. When rock is encountered, the rod may be driven at an angle not to exceed 45 degrees from the vertical.
- C. Ground ring conductors shall be bare No. 2/0 AWG copper installed minimum 2-1/2 feet below finished grade.
- D. Conductors encased in concrete footings, floor slabs or duct banks shall be bare copper, No. 2/0 AWG unless otherwise noted.
- E. Building structural steel or metal framing shall be connected at all points indicated on the Drawings.

3.2 EQUIPMENT GROUNDING CONDUCTORS

- A. A separate insulated green copper conductor shall be installed as an equipment grounding conductor in all raceway and with every feeder, branch circuit and control circuit. This shall be in addition to the grounded metallic conduit system.
- B. All equipment grounding conductors shall be terminated at both ends.

3.3 GROUNDING ELECTRODE CONDUCTOR

- A. The electrical service and all separately derived systems shall be grounded in accordance with NEC Article 250.
- B. The grounding electrode conductor shall be copper, sized in accordance with NEC Article 250 or as shown on the Drawings.

3.4 CONNECTIONS

- A. All conductors below grade or encased in concrete and all connections to building steel shall be exothermic weld.
- B. Connections to equipment ground busses or pads shall be compression type lugs, bolted to the bus or pad.
- C. Grounding connections shall be made to clean, dry surfaces. All scale, rust, paint, grease and other contamination shall be removed prior to making connections. Upon completion of welded connections all slag shall be removed.

3.5 RACEWAY AND EQUIPMENT

- A. All raceway and noncurrent carrying metal equipment and enclosures shall be electrically continuous and bonded to the grounding system.
- B. Where equipment is provided with a ground bus all equipment grounding conductors shall be terminated on the bus. The Contractor shall perform all drilling and tapping required and provide all hardware.

3.6 BONDING TO OTHER SYSTEMS

- A. An accessible means for connecting intersystem bonding and grounding conductors shall be provided.
- B. Interior metal water piping and sprinkler piping shall be bonded in accordance with NEC ART 250-80.

END OF SECTION 16070

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SECTION 16110

RACEWAY AND FITTINGS

PART 1 - GENERAL

1.1 GENERAL

- A. Provisions of Section 16010 General Requirements for Electrical Work apply to the work of this Section.

1.2 CODES AND STANDARDS

- A. Products shall comply with the following codes and standards and shall be UL-listed and labeled:

ANSI C80.1	Standard for Rigid Steel Conduit
NEMA TC-2	Electrical Plastic Tubing and Conduit
NEMA TC-3	PVC Fittings for use with Rigid PVC Conduit and Tubing
UL 1	Flexible Metal Conduit
UL 6	Rigid Metal Conduit
UL 360	Liquid Tight Flexible Steel Conduit
UL 514B	Fittings for Conduit and Outlet Boxes
UL651	Schedule 40 and 80 Rigid PVC Conduit
UL797	Electrical Metallic Tubing
UL870	Wireways, Auxilliary Gutters and Associated Fittings

PART 2 - PRODUCTS

2.1 CONDUIT

- A. Rigid steel conduit shall be of mild steel piping with a uniform protective coating of hot dipped galvanizing inside and outside, including all threads. The conduit shall be furnished in nominal 10-foot lengths, with both ends threaded and one coupling (galvanized inside and out) applied to each length. The threads opposite the coupling end shall be protected by a plastic cap.
- B. Rigid aluminum conduit, couplings and elbows shall be manufactured of a suitable copper-free aluminum alloy. Conduit lengths shall be seamless throughout and shall have hard, smooth and gum-free interior coatings to facilitate the pulling-in of conductors. It shall be furnished in nominal 10-foot lengths, with both ends threaded and a coupling applied to one end of each length. Threads on the coupling end shall be coated with a special lubricant so that the coupling may be removed without difficulty. Threads on the end opposite the coupling shall be protected from damaged by a plastic cap.
- C. Plastic coated rigid steel conduit shall have a 40 mil polyvinyl chloride coating fused to the exterior of the conduit and a urethane coating on the interior and over the threads. The conduit shall be hot dipped galvanized inside and out before the PVC coating is applied. All couplings and fittings shall be similarly coated and shall have overlapping sleeves for the sealing of all joints.

- D. Rigid nonmetallic conduit shall be heavy wall Schedule 40 polyvinyl chloride 90°C rated furnished in 10-20-, or 30-foot lengths.
- E. Electrical metallic tubing shall be of zinc coated steel with an interior coating of lacquer or enamel.
- F. Liquid tight flexible conduit shall be constructed with a flexible core of galvanized steel and an oil resistant PVC jacket to form a liquid tight raceway. The overall jacket shall be wrinklefree and suitable for use in temperatures from -40 deg. C to + 100 deg. C.
- G. Flexible metal conduit shall be hot dipped galvanized interlocked strip steel.

2.2 CONDUIT FITTINGS

A. Bushings.

- 1. Insulated bushings for conduit sizes 1-1/4 inches and larger shall have metal bodies and threads, with molded-on high impact phenolic thermosetting insulation to prevent conductor insulation damage. Bushings shall be Type IBC insulated bushings as manufactured by O.Z./Gedney or an approved equal. Insulated bushings for conduit sizes 1 inch and smaller may be of plastic, O.Z./Gedney Type "A", or an approved equal.
- 2. Insulated grounding bushings shall be similar to the insulated bushings described above, except they shall have set screws to lock the bushings on the conduits and shall have mechanical type lugs attached. The lugs shall be sized to accept the ground wire sizes as set forth in the latest edition of the National Electrical Code, but in no case smaller than No. 8 AWG wire. Grounding bushings shall be Type BLG as manufactured by O.Z./Gedney or an approved equal.
- 3. Male bushings shall be Thomas and Betts Corporation insulated throat chase nipples, or a product of equal construction. Bushings used only to pass conductors through metal partitions, etc. shall be O.Z./Gedney, Type "ABB".
- 4. Bushings for use with EMT shall be O.Z./Gedney type SBT or approved equals.

B. Conduit bodies for use with aluminum conduit shall be of copper free aluminum alloy. Those for use with steel conduit may be of galvanized, or cadmium plated cast iron, or of copper free aluminum alloy. All conduit fittings shall be provided with neoprene gaskets and sheet metal covers, except that cast covers shall be used for sized 1-1/2 inches and larger. Conduit connections shall be threaded and EMT connections shall be set screw. Cover screws shall be captive. All conduit fittings shall be Crouse Hinds, Appleton, Killark or approved equal.

C. Hubs. Water-tight conduit connections are required on all NEMA 3R, 4, and 4X enclosures and all electrical equipment located outdoors or in damp or wet areas. Where hubs or water-tight threaded connections are not provided as part of the enclosure, water-tight hubs shall be Myers "Scrutite", or approved equal. All other terminations shall be double locknut and bushing.

- D. Fittings for use with liquid-tight flexible conduit shall be zinc plated malleable iron O.Z./Gedney type 4Q or approved equal.
- E. Locknuts. Locknuts shall be hot dipped galvanized steel or malleable iron. Standard locknuts shall be used for connections to NEMA 1 enclosures. Sealing locknuts with integral gasket shall be used for connections to NEMA 12 enclosures.

2.3 JUNCTION BOXES

- A. Pull and junction boxes shall be of code gauge metal with continuously welded joints or of cast metal if called for on the Drawings. All junction boxes shall have gasketed screw covers. Boxes for use with aluminum conduits shall be of aluminum. Sheet steel boxes shall be galvanized after fabrications. Screws for galvanized steel box covers shall be made of brass. Screws for aluminum box cover shall be stainless steel.
- B. Boxes installed in concrete shall be cast iron alloy or copper free aluminum.
- C. Unless otherwise shown on drawings, all boxes installed indoors shall be rated NEMA 1 and all boxes installed outdoors shall be rated NEMA 3R.
- D. Pullboxes used in the electrical duct bank system for communications/security and emergency power circuits, shall be constructed of polymer concrete and reinforced with heavy weave fiberglass capable of a service load rating of 8000# over a 10"square. Pullboxes shall be provided with stacked extensions for a minimum depth of 39". Pullboxes shall be provided with stainless steel penta-head bolts. Pullboxes shall be 24" x 36", model PG as manufactured by Quazite, or approved alternate.

2.4 OUTLET BOXES

- A. Outlet boxes for concealed work shall be pressed steel boxes, galvanized and not less than #12 gauge. Each ceiling outlet designated for a lighting fixture shall have a fixture support secured in place with bolts and nuts. Ceiling boxes shall be octagonal with lugs and screws for back plates.
- B. Outlet boxes installed outdoors, in concrete or exposed, shall be cast iron alloy or copper free aluminum with gasketed covers.
- C. Provide outlet box accessories as required for each installation, including box supports, mounting ears and brackets, wallboard hangers, box extension rings, fixture studs, cable clamps and metal straps for supporting outlet boxes, which are compatible with outlet boxes being used and to fulfill installation requirements for individual wiring situations.

2.5 WIREWAY

- A. Wireway shall be lay-in type, code gauge steel with dark gray enamel finish inside and out.
- B. Covers shall be hinged with captive screw fasteners for NEMA 1 & NEMA 3R wireway and gasketed quick release latch covers for NEMA 12 wireway.

2.6 SUPPORTS

- A. The Electrical Subcontractor shall size and provide all supports necessary for the installation of all raceway.
- B. Channel framing shall be manufactured by Unistrut, Kindort, B-Line or approved equal.
- C. In dry, non-corrosive areas, channel framing and angle shall be galvanized steel or aluminum and all nuts, bolts and hardware shall be carbon steel, cadmium plated or hot dipped galvanized. Ream clamps shall be galvanized steel or malleable iron.
- D. In outdoor, wet or damp areas channel framing and angle shall be aluminum or 304 stainless steel and nuts, bolts and hardware shall be 304 stainless steel. Beam clamps shall be hot dipped galvanized steel or malleable iron.
- E. Supports shall be sized with a minimum safety factor of four or 200 lbs. whichever is greater.

PART 3 - EXECUTION

3.1 GENERAL

- A. Wiring methods are specified in Section 16010 General Requirements for Electrical Work.

3.2 INSTALLATION

- A. Conduit, EMT, boxes & enclosures shall be installed so that they are mechanically secure, electrically continuous and neat in appearance.
- B. Exposed runs shall be installed to conform to the shape of the surface over which they are run. Where they are run over a plane surface, they shall be straight and true. All exposed conduits shall be run parallel and perpendicular to building column lines and walls. Diagonal run will not be permitted. Conduit runs in groups shall be supported by means of common members made of channel framing. Group mounting is not required where the group consists of only two conduits. Fastening to solid masonry or concrete shall be machine bolts with expansion shields. Fastening to hollow masonry shall be with toggle bolts.
- C. Unless otherwise approved, spacing between conduit supports shall not exceed ten feet. Conduits shall not be supported from structural members marked "Removable" on the structural drawings. Conduit hangers and supports shall be fastened to buildings and structural members only and not to any equipment or piping. Separate conduits a minimum of 6" from flues, steam and hot water lines. Install conduit above mechanical piping wherever possible.
- D. All conduit supports other than structural members shall be galvanized. The use of perforated strap or plumber straps will not be permitted.
- E. Conduit up to 1-1/2 inches may shall be supported by one-hole malleable iron straps with clamp backs. Conduit 2 inches and larger shall be supported by two-hole straps.
- F. Conduit runs shall not exceed 100 feet between boxes, fittings or devices.

- G. All conduit crossing building or structure expansion joints shall be provided with approved expansion fittings.

3.3 BENDS

- A. Field bends shall be made with approved bending tools. All field-formed bends shall be of maximum radius permitted by the design and construction conditions.
- B. Where a group of exposed conduits change direction, the bends shall have a common center in order to maintain the uniformity and neat appearance of the group, having regard for the minimum bending radius of the largest conduit in the group.
- C. Bends shall be uniform radius and free from cracks, crimps or other damage to the conduit or its coating and shall not unduly flatten the conduit section.

3.4 JOINTS AND TERMINATIONS

- A. All joints in rigid conduit shall be threaded, using standard couplings. The use of running threads, threadless or split couplings is prohibited. When reaming out of conduit ends to remove burrs and rough edges, care shall be exercised to avoid excessive reaming which results in the weakening of the conduit wall at the end.
- B. All joints shall be made up wrench tight and with a minimum of wrench work in order to avoid wrench cuts.
- C. All cut threads shall be thoroughly painted with a coating of a rust inhibiting primer.
- D. EMT couplings and fittings shall be compression type up to 1 -1/4 inch and double set screw type 1-1/2 inch and larger.
- E. All conduit terminations in panels, enclosures, outlet boxes and equipment shall be provided with bushings.

3.5 FLEXIBLE CONDUIT

- A. Flexible conduit shall be use to terminate all, lighting, motors, unit lanterns, transformers, pilot devices and vibrating equipment.
- B. Liquitite flexible conduit and fitting shall be used outdoors and in all damp or wet areas, or where exposed to grease or oil.
- C. Connections to lighting fixtures shall be maximum length of 6 feet. All other flexible connections shall be maximum 18 inches.

3.6 PENETRATIONS

- A. All penetrations through concrete slabs, masonry walls or roofs shall be provided with sleeves.

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- B. All sleeves shall be sealed to maintain the integrity of the structure. Fire resistant walls and floors shall be sealed with approved material, and shall maintain the original fire rating. All seals below grade shall be watertight, O.Z./Gedney type WSK or approved equal.

END OF SECTION 16110

SECTION 16200

600 VOLT WIRE

PART 1 - GENERAL

1.1 GENERAL

- A. The provisions of Section 16010, General Requirements for Electrical Work apply to the Work of this Section.

1.2 CODES AND STANDARDS

- A. Products shall comply with the following codes and standards and shall be UL-listed and labeled:

ASTM B-3	Soft or Annealed Copper Wire
ASTM B-8	Concentric Lay Stranded Copper Conductors
NEMA WC-5	Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
UL 44	Rubber Insulated Wires and Cables
UL 83	Thermoplastic Insulated Wires and Cables

1.3 SUBMITTALS

- A. Manufacturer's product data sheets.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All conductors shall be annealed copper in accordance with ASTM B-3.

- B. The jacket of all wire shall be printed with the following information:

1. Manufacturer
2. Size
3. Insulation type
4. Maximum voltage
5. UL label

- C. All insulation shall be rated 600 volt

2.2 POWER WIRING

- A. Service lateral and service entrance conductors shall be type XHHW.

- B. Feeders and motor branch circuits shall be type THHN/THWN.

- C. All power wiring shall be stranded, Class B strand in accordance with ASTM B-8, minimum size #12 AWG.

2.3 BRANCH CIRCUITS

- A. All lighting and convenience receptacle branch circuit wiring shall be type THHN/THWN.
- B. Branch circuit wiring shall be solid or stranded conductor, minimum size #12 AWG.

2.4 CONTROL WIRING

- A. Wiring for control circuits shall be THHN/THWN.
- B. Control wiring shall be stranded, Class B strand in accordance with ASTM B-8, minimum size #14 AWG.

2.5 FIXTURE WIRE

- A. Where high temperature fixture wire is required it shall be silicone rubber type SF-2.

PART 3 - EXECUTION

3.1 GENERAL

- A. All wire shall be installed in accordance with Section 16060, Installation of Wire and Cable.
- B. All wire shall be tested in accordance with Section 16030, Electrical Acceptance Testing.

END OF SECTION 16200

SECTION 16415

MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 GENERAL

- A. The provisions of Section 16010, General Requirements for Electrical Work apply to the Work of this Section.
- B. The work of this section includes locally installed, enclosed combination magnetic motor starters and manual motor starters.

1.2 CODES AND STANDARDS

- A. Products shall comply with the following codes and standards and shall be UL listed and labeled.

NEMA ICS-2	Industrial Control Devices, Controllers and Assemblies.
UL 508	Industrial Control Equipment.

1.3 SUBMITTALS

- A. Manufacturers Product Data Sheets
- B. Dimensioned Outline Drawings.
- C. Control wiring diagrams.

1.4 MANUFACTURERS

Subject to compliance with the specification requirements.

Siemens
General Electric
Square D
Cutler Hammer

PART 2 - PRODUCTS

2.1 MAGNETIC MOTOR STARTERS

- A. Unless otherwise noted, magnetic motor starters shall be NEMA rated full voltage type. The disconnecting means shall be circuit breaker type, nonfused or fused switch as shown on the Drawings. Minimum starter size shall be NEMA 1.

- B. All components including the disconnecting means shall be installed in a single enclosure rated NEMA 1 for indoor locations and NEMA 4 for wet, damp and outdoor locations.
- C. The disconnecting means shall be provided with an external operating handle which is interlocked to prevent opening the door when the handle is in the ON position and prevent closing the disconnect when the door is opened. The interlock shall be defeatable. The handle shall be padlockable in the OFF position.
- D. Circuit breakers shall be adjustable magnetic trip, motor circuit protector type.
- E. The short circuit rating of the assembly shall be 10,000 A RMS symmetrical.
- F. Each motor starter shall be provided with a control power transformer to provide 120 VAC control power. The transformer shall be provided with two primary fuses and one secondary fuse. The transformer shall be extra capacity with a minimum rating of 100 VA.
- G. Overload relays shall be three-pole, trip free, manually reset Class 20, bimetallic, ambient compensated type with an external reset mechanism.
- H. Contactor coils shall be provided with surge suppressors.
- I. Sufficient auxiliary contacts shall be provided for all interlocks. A minimum of one normally opened and one normally closed spare contacts shall be provided.
- J. Door mounted pilot devices shall be heavy-duty oil tight. Pilot lights shall be transformer type. A HAND-OFF-AUTO maintained contact selector switch, red RUN and green READY pilot lights shall be provided on each enclosure.
- K. All control wiring shall be brought to terminal blocks for connection of field cabling. Minimum wire size shall be #14 AWG.
- L. Connections for motor leads shall be suitable for copper conductors applied at their 75°C rating.

2.2 MANUAL MOTOR STARTERS

- A. Single phase fractional HP manual motor starters shall be toggle operated, enclosed, one or two pole switches as required by the installation.
- B. The enclosure shall be NEMA 1 for indoor locations and NEMA 4 for outdoor, wet and damp locations. A handle guard shall be provided to allow the toggle operator to be padlocked in the OFF position.
- C. Starters shall be provided with trip free melting alloy overloads.

PART 3 - EXECUTION

- 3.1 Equipment shall be installed in accordance with Section 16050, Installation of Electrical Equipment.
- 3.2 The Contractor shall verify motor nameplate amperes and motor service factors and shall provide all overload heater elements and fuses. Overload heater elements shall be sized in accordance with motor nameplate amperes.

END OF SECTION 16415

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SECTION 16420

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 GENERAL

- A. The provisions of Section 16010, General Requirements for Electrical Work apply to the work of this section.
- B. The equipment shall be completely assembled, wired and tested at the manufacturer's factory or in a factory authorized distributor's facility.
- C. The manufacturer shall have a local service representative to provide start-up and warranty service.
- D. The manufacturer shall review speed, load and torque data provided for the driven equipment and verify that the drive(s) will provide sufficient starting torque and will function properly over the entire intended speed range.
- E. Acceptable manufacturers are:

Toshiba/Houston
Allen-Bradley
Eaton
ABB
Magnetek

1.2 CODES AND STANDARDS

- A. Products shall comply with the following codes and standards and shall be UL listed and labeled.

IEEE Std 519 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

1.3 SUBMITTALS

- A. Outline drawings showing overall dimensions, weight, mounting details, spacing requirements, and cooling requirements.
- B. Assembly drawing identifying all components and their location in the panel.
- C. Schematic diagram for 120 VAC control.
- D. Terminal block drawing showing connection points for all customer wiring.

- E. Catalog cuts and descriptive information for the drive, drive accessories and options.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Variable frequency drives shall be pulse width modulated (PWM) with diode bridge rectifiers, transistorized inverters and microprocessor based digital control.
- B. Each drive shall have a rating in horsepower (HP) equal to or greater than the motor name plate horsepower and each drive shall have a continuous output current rating equal to or greater than the motor full load amperes (FLA).
- C. All components shall be assembled in a single NEMA 1, metallic, self ventilated enclosure.
- D. Drives shall be designed for continuous duty in a 40 degree C ambient temperature.
- E. Drives may be variable or constant torque in accordance with the load requirements.
- F. Power supply will be 208 volts (+10%), 3 phase, 60 hz, (+2 Hz) on a solidly grounded system.
- G. Drives shall be provided with line isolation transformers sized by the manufacturer.

2.2 CONTROLLER SPECIFICATIONS

- A. Output Frequency: 0 to 60 Hz.
- B. Frequency Accuracy: + 0.5%
- C. Overload Rating: 150% for one minute
- D. Efficiency: 95% minimum
- E. Displacement Power Factor: 0.95 nominal

2.3 CONTROL

- A. The drive shall be capable of local and remote control.
 - 1. A door mounted HAND/OFF/AUTO (H/O/A) selector switch to select between manual (HAND) and remote (AUTO) run control shall be provided. The RUN control circuit shall be 120 VAC obtained from a control power transformer installed in the drive cabinet. Transformer shall have additional 100 VA capacity for customer use. A remote RUN contact to start and stop the drive in the AUTO mode will be provided by others. No external sources of control power shall be required.

2. Door mounted manual speed adjust control shall be provided. This may be incorporated as a function in the keypad or a separate door potentiometer may be provided. The manual speed adjust control shall function when the H/O/A switch is in the HAND position.
3. Remote speed adjustment shall be 4-20 mA DC and shall control the drive when the H/O/A switch is in the AUTO position.
4. A door mounted maintained contact EMERGENCY STOP push button and emergency stop relay shall be provided. The relay coil shall be 120 VAC with wiring brought to terminal points for connection of remote emergency stop contacts. The relay shall initiate an external drive fault condition and be wired directly to and de-energize the output contactor.
5. Each drive shall be furnished with a door mounted operators keypad and alphanumeric display. The keypad shall be capable of programming, setting and adjusting all drive parameters. The display shall indicate drive status, speed, and fault conditions.
6. The drive shall be provided with current transformers and a door mounted percent load meter.
7. One set of Form C dry contacts rated 120 VAC shall be provided for customer use for each of the following functions:
 - o Drive RUN
 - o Drive FAULT
8. A 4-20 mA output shall be provided for the following functions:
 - o Output FREQUENCY
9. Provide red door mounted transformer type pilot lights for the following functions:
 1. Power ON
 2. Drive RUN
10. Provide a door mounted Run Time Meter.

1.4 OPERATIONAL FUNCTIONS

- A. The drive shall include the following user adjustable functions.
 1. Maximum Frequency
 2. Minimum Frequency
 3. Frequency Skips with adjustable band width Three (3)
 4. Acceleration Time
 5. Deceleration Time
 6. Torque Boost

7. Volts/Hertz
8. Preset Speeds

1.5 PROTECTIVE FEATURES

- A. The drive shall include the following protective features.
 1. External Signal Trip
 2. Phase sequence
 3. Phase loss
 4. Undervoltage
 5. Overvoltage
 6. Overcurrent
 7. Overtemperature
- B. Current limiting input line fuses shall be provided and sized by the manufacturer for proper drive protection.
- C. The drive shall include adjustable electronic overload protection to provide motor running overload protection in accordance with NEC Article 430 Part C.

1.6 DISCONNECT

- A. A disconnect switch shall be provided as a means of disconnecting the incoming 208V, 3-phase power. All power in the enclosure shall be deenergized when the disconnect is opened.
- B. The external operating handle shall be pad lockable in the OFF position.

1.07 CONTACTORS

- A. A NEMA or IEC rated output contactor shall be provided. Contactor coil shall be interlocked with the emergency stop relay.
- B. Surge suppressors shall be provided on all contactor coils.

1.8 ENCLOSURE

- A. The drive and all components shall be installed in a single NEMA 1 metallic gasketed enclosure.
- B. The enclosure shall be suitable for top or bottom conduit entry.
- C. Cabinet ventilation shall be arranged such that two or more drive cabinets may be placed next to each other.
- D. Cabinet shall be front access only and suitable for mounting against a wall.

- E. The cabinet shall be provided with a copper equipment ground bus. A bonding jumper shall be provided between the enclosure and the door.

1.9 WIRING

- A. Power and control wiring shall be segregated from wiring sensitive to noise.
- B. Control wiring shall be No. 14 AWG stranded or larger.
- C. Signal leads shall be No. 16 AWG shielded, 600 volt insulation.
- D. Easily accessible and labeled terminal strips shall be provided for signal leads and 120 volt control field connections.
- E. Each wire or cable termination, except for printed circuit board connections, shall be clearly and permanently identified with wire numbers at both ends.
- F. Connections to equipment located on the doors and hinged frames shall be flexible, looped and arranged to prohibit chafing on the edges of the door or frame or interference in any way with the operation of other equipment.

PART 3 - EXECUTION

- 3.1 Drives shall be installed in accordance with manufacturers written instructions and Section 16050, Installation of Electrical Equipment.
- 3.2 The drive manufacturer shall provide start-up service assistance for drive set-up, adjustment and field checking and testing.

END OF SECTION 16420

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SECTION 16450

TRANSIENT VOLTAGE SURGE SUPPRESSION

PART 1- GENERAL

1.1 GENERAL

- A. The provisions of Section 16010 General Requirements for Electrical Work apply to the Work of this Section.
- B. This section describes the materials and installation requirements for surge protection devices for the protection of AC electrical circuits from the effects of lightning induced currents, substation switching transients and internally generated transients resulting from inductive and/or capacitive load switching.

1.2 CODES AND STANDARDS

- A. Products shall comply with the following codes and standards and shall be UL-listed and labeled:

NFPA 70	National Electrical Code
NFPA 780	Standard for the Installation of Lightning Protection Systems
UL 1449	Transient Voltage Surge Suppression
ANSI/IEEE C62.41	8x20 Single Impulse Current Test

1.3 SUBMITTALS

- A. Manufacturer's product data sheets, shop drawings and system layout drawings shall be submitted for approval prior to installation. Layout drawings shall include locations of all devices and required connections. Product data shall include manufacturer's written recommendations for installation.

1.4 MANUFACTURERS

- A. Subject to compliance with the Specification requirements:

Square D
Cutler Hammer
Siemens
General Electric
Erico/Critec

PART 2 - PRODUCTS

2.1 GENERAL

- A. TVSS modules may be provided remote mounted or integral to the panelboard or switchboard the device is directly protecting. However, if the manufacturer, supplier or contractor decides to provide this as a remote mounted assembly, all components including but not limited to breakers, wiring, and conduit required by this installation shall be provided by the contractor at no additional cost to the owner. Remote mounted assembly shall be provided in a NEMA 1 enclosure or as indicated by the drawings.
- B. TVSS system shall be UL Listed.
- C. Service entrance TVSS system shall be suitable for use in service entrance locations.
- D. TVSS shall be Metal Oxide Varistor (MOV) based, however, silicon avalanche diode (SAD) and combination MOV and SAD systems will be considered if submitted.
- E. TVSS protection shall be for all modes of protection, Line-to-Line/Line-to-Neutral, Line-to-Ground, and Ground-to-Neutral. The maximum surge current capability shall be at least 160kA for service entrance (category A) TVSS unit and 100kA for local and branch panel (category B and C) devices. Maximum surge capability shall be measured as the sum of the Line-to-Neutral value plus the Line-to-Ground value.
- F. The UL component suppression voltage ratings shall not exceed the following:

Voltage	Line-to-Neutral	Line-to-Ground	Neutral-to-Ground	Line-to-Line
208Y/120V	400V	400V	400V	700V

- G. The ANSI/IEEE C62.41 (1991) Category C3 let through voltages shall not exceed the following:

Voltage	Line-to-Neutral	Line-to-Ground	Neutral-to-Ground
208Y/120V	520V	520V	520V

- H. Unit shall be capable of protecting against and surviving 5000 ANSI/IEEE C62.41 Category C transients without failure.
- I. Each TVSS shall be designed to withstand a maximum continuous operating voltage (MCOV) of not less than 115% of nominal RMS voltage.
- J. TVSS shall be provided with onboard visual and audible diagnostic monitoring. Indicator lights/LED's shall provide fulltime visual diagnostic monitoring of the operational status of each phase of the surge current diversion module and shall differentiate full operation, reduced system operation and system failure. An audible alarm shall be provided to indicate a fault condition.
- K. Main service TVSS shall be provided with a surge counter which displays the number of transient surges detected from line-to-ground, line-to-line, line-to-neutral and neutral-to-ground.

PART 3 - EXECUTION

3.1 INSTALLATION AND TESTING

- A. Panelboards shall be installed in accordance with Section 16050, Installation of Electrical Equipment.
- B. Remote mounted TVSS units shall be mounted as close to the electrical panel they are fed from as possible and shall use short, straight wiring runs with minimum slack, no extra turns and no loops to minimize circuit inductance and shall not exceed manufacturer's recommended maximum distance of installation.
- C. TVSS shall be provided with a five-year warranty.

END OF SECTION 16450

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SECTION 16470

PANELBOARDS

PART 1 - GENERAL

1.1 GENERAL

- A. The provisions of Section 16010, General Requirements for Electrical Work apply to the Work of this Section.

1.2 CODES AND STANDARDS

- A. Products shall comply with the following codes and standards and shall be UL-listed and labeled:

NEMA AB-1	Molded Case Circuit Breakers
NEMA PB-1	Panelboards
UL 50	Enclosures for Electrical Equipment
UL 67	Panelboards
UL 489	Molded Case Circuit Breakers and Circuit Breaker Enclosures
UL 943	Ground Fault Circuit Interrupters

1.3 SUBMITTALS

- A. Manufacturer's product data sheets.
B. Circuit breaker schedules.

1.4 MANUFACTURERS

- A. Subject to compliance with the Specification requirements:

Square D
Cutler Hammer
General Electric
Siemens

PART 2 - PRODUCTS

2.1 GENERAL

- A. Panelboards, including lighting and appliance panelboards and power distribution panelboards, shall be of the sizes, rating and arrangement shown on the Drawings.
B. Panelboards shall be provided complete with all overcurrent devices, accessories and trim.
C. All panelboards shall be provided with safety barriers for dead front construction.

- D. The required short circuit ratings of assembled panelboards are shown on the Drawings. The short circuit rating of every overcurrent device in the panel shall meet or exceed the panel rating. Unless otherwise noted on the Drawings, series rated combinations will not be permitted.

2.2 CABINETS

- A. Boxes shall be code gauge galvanized sheet steel.
- B. Trim shall be code gauge steel, ANSI-61 gray finish with stainless steel flush type lock/latch handle. All locks shall be keyed alike.
- C. Trim for surface mounted panels shall be door-in-door construction such that the gutter space may be exposed by a hinged door.
- D. Directory frames shall be metal frame with plastic covers.

2.3 BUS

- A. All bus work shall be 1000 amp/sq.in. copper.
- B. Unless otherwise noted on the Drawings, neutral busses shall be 100% rated with adequate connections for all outgoing neutral conductors.
- C. Panelboards shall be provided with copper ground busses.
- D. Bus shall be designed for sequence phase connection to allow the installation of one, two or three pole branch circuit breakers in any position.

2.4 OVERCURRENT DEVICES

- A. Overcurrent devices shall be trip-free molded case, bolt-on, thermal magnetic circuit breakers.
- B. Main circuit breakers shall be individually mounted and bolted to bus assembly. Back-fed branch mounted circuit breakers are prohibited.
- C. Front faces of all circuit breakers shall be flush. Trip indication shall be clearly shown by the handle position between the ON and OFF positions.
- D. Ground fault circuit breakers shall require no more panel space than standard breakers.
- E. Where circuit breakers are used for switching of lighting, circuits type "SWD" circuit breakers shall be provided.
- F. All connections shall be rated for 75°C copper conductors.

PART 3 - EXECUTION

3.1 PANELBOARDS

- A. Panelboards shall be installed in accordance with Section 16050, Installation of Electrical Equipment.

END OF SECTION 16470

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SECTION 16490

SAFETY SWITCHES

PART 1 - GENERAL

1.1 GENERAL

- A. The provisions of Section 16010 General Requirements for Electrical Work apply to the Work of this Section.

1.2 CODES AND STANDARDS

- A. Products shall comply with the following codes and standards and shall be UL-listed and labeled:

NEMA KS-1	Enclosed Switches
UL 98	Enclosed and Deadfront Switches

1.3 SUBMITTALS

- A. Manufacturer's product data sheets.

1.4 MANUFACTURERS

- A. Subject to compliance with the specification requirements:

General Electric
Square D
Siemens
Westinghouse

PART 2 - PRODUCTS

- 2.1 Safety switches shall be 240 VAC NEMA heavy duty, horsepower rated visible blade type. Switches shall be non-fused or fused as indicated on the Drawings.
- 2.2 The switch operating mechanism shall be spring activated quick make - quick break.
- 2.3 The external operating handle shall indicate the switch position, ON in the up position, OFF in the down position and shall be padlockable in the OFF position. A defeatable interlock shall be provided to prevent opening the cover when the switch is ON and prevent closing the switch contacts when the cover is opened.
- 2.4 Switches shall be provided with arc suppressors and line terminal shields.
- 2.5 Single speed motors shall be provided with three pole switches. Two speed motors shall be provided with six pole switches.
- 2.6 Switches shall be provided with a factory supplied ground kit.

- 2.7 Fused switches shall be provided with class J fuses.
- 2.8 Safety switches installed indoors shall be provided with NEMA 1 enclosures. Safety switches installed outdoors or in wet areas shall be provided with NEMA 4 enclosures.

PART 3 - EXECUTION

- 3.1 Safety switches shall be installed in accordance with Section 16050 Installation of Electrical Equipment.

END OF SECTION 16490

SECTION 16500

LIGHTING FIXTURES

PART 1 - GENERAL

1.1 GENERAL

- A. Provisions of Section 16010 General Requirements for Electrical Work, Section 16060 Installation of Wire and Cable, and Section 16110 Raceway and Fittings apply to the work of this section.

1.2 CODES AND STANDARDS

- A. Products shall comply with the following codes and standards and shall be UL-listed and labeled:

CBM Labels	Certified Ballast Manufacturers Assoc.
NEC Art. 410	National Electrical Code
FCC, Part 18	RFI and EMI
ANSI C62.41	Line Transient Protection
UL 1570	Fluorescent Lighting Fixtures
UL 1572	HID Lighting Fixtures
UL 1571	Incandescent Lighting Fixtures
UL 924	Emergency Lighting and Power Equipment
UL 1088	Temporary Lighting

1.3 SUBMITTALS

- A. Submit manufacturer's product data, photometrics, and installation instructions for each type of light fixture specified. Fixture submittals will be in booklet form with separate sheet for each fixture assembled in "luminaire type" alphabetical order, with proposed fixture and accessories clearly indicated on each sheet.
- B. Submit on a separate sheet for each HID and fluorescent fixture type specified, the ballast manufacturer, type and technical data for that ballast.
- C. Submit on a separate sheet for each light fixture specified, the proposed lamp and manufacturers data for that lamp.

1.4 MANUFACTURERS

- A. Provide products of the manufacturers specified on the contract drawings and as listed under Part 2 of this section.

PART 2 - PRODUCTS

2.1 **GENERAL**

- A. Light fixtures shall be provided with housings, trims, ballasts, lamp holders, sockets, reflectors, wiring and other components required, as a factory-assembled unit for a complete installation.
- B. Provide electrical wiring within light fixtures suitable for connecting to branch circuit wiring in accordance with NEC Article 410, Paragraph 25.
- C. Deliver interior lighting fixtures in factory fabricated containers and wrapping, which properly protect fixtures from damage.
- D. Store interior lighting fixtures in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, humidity, extreme temperatures, laid flat and on skids to keep off floors and ground.
- E. Fixtures installed in ceilings, suspended from ceilings or on walls shall have a plastic film covering protecting lens, louver and lamps from dust, dirt and debris. Plastic film shall not be removed until construction is completed.

2.2 **FLUORESCENT FIXTURES**

- A. General: Provide fluorescent fixtures of sizes, types and ratings indicated and specified in the Lighting Fixture Schedule on the Contract Drawings.
- B. Fluorescent-Lamp Ballasts: provide low-energy solid state fluorescent lamp ballasts, capable of operating lamp types indicated; with high power factor (>0.90), Class A sound rating. Ballasts shall have lamp current crest factor of 1.7 or less and total harmonic distortion less than 20%. Ballast factor shall be 0.88-0.90. Ballast shall be instant start for maximum efficiency and parallel wired such that if one lamp fails the remaining lamps stay lit.
 - 1. Manufacturers: Subject to compliance with the requirements, provide ballasts by one of the following:

Osram Sylvania, Inc.
Magnetek
Advance
- C. Fluorescent Dimming Ballasts: Provide solid-state electronic dimming ballasts, capable of operating lamp types specified, with high power factor rapid start, and Class A sound rating. Ballast shall have a lamp crest factor of 1.7 and below and a total harmonic distortion not to exceed 20%. Dimming capability shall be 100% to 10%.
 - 1. Manufacturers: Subject to compliance with requirements provide dimming ballasts by one of the following:

Lutron Electronics Co., Inc.
Osram Sylvania

D. Compact Fluorescent Ballasts: Provide solid-state electronic ballasts capable of operating lamp types specified. Ballasts shall have a total harmonic distortion not to exceed 20%. Ballasts shall have an end of lamp life sensing circuit capable of shutting the lamp down to prevent lamp glass from cracking and preventing lamp base and sockets from melting. Ballasts shall have a ballast factor of 0.90-1.00.

1. Manufacturers: Subject to compliance with requirements provide dimming ballasts by one of the following:

Osram Sylvania
Magnetek
Advance

E. Compact Fluorescent Dimming Ballasts: Provide solid-state electronic ballasts capable of operating lamp types specified. Ballasts shall have a total harmonic distortion not to exceed 20%. Dimming capability shall be 100% to 5%.

1. Manufacturers: Subject to compliance with requirements provide dimming ballasts by one of the following:

Lutron Electronics Co., Inc.
Osram Sylvania

2.3 INCANDESCENT FIXTURES

A. Provide incandescent fixtures of sizes, types and ratings indicated and specified in the fixture schedule. Fixtures shall have diecast aluminum lampholder housing with medium base porcelain socket. The fixtures frame shall have galvanized steel junction box with hinged covers and 1/2"-3/4" knockouts. Thermal protection shall be as required. Specular Alzak reflector cones shall be provided with color as specified.

2.4 HIGH INTENSITY DISCHARGE FIXTURES

A. Provide HID lamp ballasts, of ratings, types and makes as recommended by lamp manufacturer, which properly mates and matches lamps to electrical supply by providing appropriate voltages and impedances for which lamps are designed. Design ballast to operate lamp within the lamp's power trapezoid requirements.

2.5 LAMPS

A. Provide HID, fluorescent and incandescent lamps of types as indicated on the contract drawings. Acceptable lamp manufacturers are Osram Sylvania, Inc. and Philips Lighting Co.

2.6 OCCUPANCY SENSORS

A. Occupancy sensors of the type and model specified on the drawings shall be provided, installed and wired into the local lighting circuit in the area that the sensors are installed. The

engineer will consider equipment of another equal manufacturer, where suitable coverage can be documented.

- B. Occupancy sensors shall be self adjusting and self calibrating type as manufactured by Hubbell/Unenco or approved equal. Occupancy sensor coverage shall be sized appropriately for the room or area being controlled. Occupancy sensor types as referenced on the drawings and equivalent Hubbell/Unenco part numbers area as follows:
 - 1. Ceiling Infrared (CI) Model OMNI-IR
 - 2. Ceiling Multi-Technology (CM) Model OMNI-DT
 - 3. Ceiling Ultrasonic (CU) Model OMNI-US
 - 4. Wall Switch Infrared (SI) Model WS1200AT
 - 5. Wall Switch Multi-Technology (SM) Model LH-MT
 - 6. Wall Switch Ultrasonic (SU) Model LH-US
- C. Provide all miscellaneous equipment including but not limited to slave relays, power packs and wiring for a complete installation.

2.7 DAYLIGHTING CONTROLS

- A. Daylighting control system shall include controller, power pack and relay contact and photocell. A wall mounted override switch shall also be installed. Daylighting controller shall be adjustable type with a range of 0-75FC, as manufactured by Hubbell/Unenco, Model DLC-PC or approved equal.
- B. Provide all miscellaneous equipment including but not limited to slave relays, power packs and wiring for a complete installation

PART 3 - EXECUTION

3.1 GENERAL

- A. Examine all areas and conditions under which lighting fixtures are to be installed and structure which will support lighting fixtures. Notify the Contractor in writing of any conditions detrimental to proper installation and completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.
- B. Coordinate light fixture installations with other trades. Fluorescent light fixtures should be installed at least two feet away from smoke detectors. Coordinate all lighting fixtures with mechanical piping and ductwork to allow for proper clearance.

3.2 INSTALLATION

- A. Install all lighting fixtures at locations and heights indicated, in accordance with the architectural reflected ceiling plans.
- B. All recessed lighting fixtures installed in ceiling which require a fire resistance rating shall be installed in accordance with the 1996 BOCA National Building Code Section 713.

- C. Provide fixtures and/or fixture outlet boxes with hangers, channel or other method of fastening and supporting fixtures required for proper installation.
- D. All pendant mounted fixtures shall be installed plumb and level or as detailed on the Contract Drawings. Pendant mounted fixtures longer than 18" shall have twin hangers of type specified.
- E. Tighten connectors and terminals, including screws and bolts in accordance with equipment manufacturer's published torque tightening values for equipment connectors. All screws and bolts shall have washers.

3.3 SPLICES AND TERMINATIONS

- A. Twist on wire connectors shall be installed which utilize square-wire spring grips and thermo plastic shells. Install connectors to meet the manufacturer's torquing requirements. Install wire connectors of size required as not to exceed the manufacturers UL-listed CSA recognized wire combinations.

3.4 FIELD QUALITY CONTROL

- A. At date of substantial completion, all lamps that are not functioning, have color deficiencies, or are noticeably dimmed shall be replaced with new lamps as determined by the Engineer.
- B. All lamps used for temporary lighting in new light fixtures shall be replaced with new lamps.
- C. All light fixtures shall be cleaned of dirt and debris upon completion of construction. All finger prints and smudges shall be cleaned.
- D. All installed fixtures during remainder of construction shall be protected in accordance with Section 2.1 Paragraph E of this specification section.
- E. All light fixtures shall be grounded in accordance with article 250 and 410 of the NEC. Tighten connections to comply with tightening torques specified in UL 486A to assure permanent and effective grounds.
- F. All light fixtures damaged in shipping or during installation shall be replaced with new fixtures at no cost to the Owner.
- G. Furnish stock or replacement lamps amounting to 15%, but no less than six lamps, of each type and size lamp used in each type of lighting fixture. Deliver replacement stock as directed to Owner's storage space.

END OF SECTION 16500

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SECTION 16624

PORTABLE GENERATOR AND MANUAL TRANSFER SWITCH ASSEMBLY

PART 1 - GENERAL

1.1 SUMMARY

- A. This specification covers requirements for providing and acceptance testing for a complete and operational portable generator and manual transfer switch assembly. This system is designed to provide backup power to the three sump pump assemblies in the basement during extended power outages and will require the owner to wheel out the generator, plug it in, manually start the generator and manually transfer the load. It is not intended for life safety or emergency power.

1.2 MANUFACTURERS

- A. The portable generator shall be as manufactured by Honda, or approved equal. The manual transfer switch assembly shall be as manufactured by Gen/Tran, or approved equal.
- B. All products specified under this section shall be warranted by the manufacturer or a factory authorized dealer unconditionally for a period of one year from date of acceptance by the Owner.

1.3 SUBMITTALS

- A. Manufacturers data and catalog cuts on the generator and manual transfer switch assembly shall be provided.
- B. Dimensioned outline drawings indicating weights, components, accessories, and field connections.
- C. Electrical drawings including schematic and connection diagrams showing terminal block identification and arrangement, field and unit wiring connection. Drawings shall be specific to this installation and show all equipment being provided and wired. Typical wiring diagrams are unacceptable.
- D. Summary test reports for prototype tests and certified reports for production tests.
- E. Statement of warranty.

PART 2 - PRODUCTS

2.1 PORTABLE GASOLINE GENERATOR

- A. The engine generator shall be gasoline fueled, 4-stroke engine with electronic ignition and automatic voltage regulation.

- B. Generator shall be capable of 120/240V single phase AC output, with 6500W maximum output, and rated for a minimum of 5500W. Generator shall be capable of starting all loads provided from the MTS panel as shown on the drawings.
- C. Generator shall be provided with a 30A, 125/250V, NEMA L14-30P locking plug receptacle for supplying power to the MTS assembly.
- D. Generator shall be provided with a heavy-duty, one-piece, welded frame with reinforced standing legs, two-wheels and handles for easy deployment.
- E. Generator shall be provided with a 6.6 gallon minimum fuel tank. Tank size shall be capable of providing power for a minimum of 10 hours when generator is running at 50% rated load. Generator shall be provided with a fuel gauge.
- F. Generator shall be provided with USDA-qualified spark arrestor and muffler, noise level shall not exceed 75dB at rated load.
- G. Generator shall be provided with storage cover.
- H. Generator shall be as manufactured by Honda Power Equipment, Model EM6500, or approved equal.

2.2 MANUAL TRANSFER SWITCH (MTS) ASSEMBLY

- A. Provide 2-pole, 60 amp MTS assembly in a NEMA 1 enclosure. Manual transfer shall be made through the use of mechanically interlocked main breakers. System must be interlocked to avoid back feeding of the utility service as required by the NEC.
- B. The MTS assembly shall include a panelboard with copper bus, and spaces for 10 branch circuits, with circuit breakers provided as shown on the drawings.
- C. The MTS shall be provided with a weatherproof power inlet box and all required power cords and accessories required for a complete and operable installation. MTS shall be compatible for use with a maximum generator size of 7500W.
- D. The switch assembly shall be listed under UL Standard 1008.
- E. MTS shall be as manufactured by Gen/Tran Model 301060 Powerstay System, or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION OF DIESEL ENGINE-DRIVEN GENERATOR SETS

- A. Install MTS system as indicated, in accordance with the equipment manufacturer's written instructions, and with recognized industry practices.

3.2 TESTING OF MTS AND GENERATOR SYSTEM

- A. The generator and MTS assembly shall be tested prior to final acceptance. Supply of power by the generator through the MTS shall be simulated with all pumps running to load test the

THE ALTON E. "CHUCK" CIANCHETTE SCOUT SERVICE CENTER
PINE TREE COUNCIL, BOY SCOUTS OF AMERICA
PORTLAND, MAINE
assembly.

3/31/04

3.3 BUILDING OPERATING PERSONNEL TRAINING

- A. Provide on-site training for Owner's building personnel in procedures for starting up, testing, operating, and maintaining the MTS and generator.

END OF SECTION

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SECTION 16700

FIRE ALARM SYSTEMS

PART 1 - GENERAL

1.1 GENERAL

- A. Provisions of Division 1 and Section 16010 *General Requirements for Electrical Work* apply to the work of this section.
- B. The work of this section includes providing a complete microprocessor based, addressable, analog fire alarm system including all initiating and notification devices, controls, software, programming, accessories, raceway, wiring, terminations, documentation, testing and start-up services.

1.2 CODES AND STANDARDS

- A. The Fire Alarm System shall comply with the following codes and standards:
 - 1. NFPA 72 National Fire Alarm Code
 - 2. NFPA 70 National Electric Code
 - 3. NFPA 13 Sprinkler Systems
 - 4. ADA Americans Disabilities Act
- B. All equipment shall be UL listed.
- C. The system shall comply with all State and Local Codes including the latest edition of the Massachusetts State Building Code and the requirements of the local Fire Department.

1.3 SUBMITTALS

- A. Manufacturer's product data sheets and installation instructions.
- B. Complete system one line and wiring diagrams.
- C. Battery calculations.
- D. Operation and Maintenance instructions.
- E. Floor plans showing wiring, location, address, and zone identification of each device.

1.4 MANUFACTURERS

- A. Subject to compliance with the Specification requirements:
 - 1) Notifier
 - 2) Pyrotronics
 - 3) Simplex
 - 4) Faraday
 - 5) Approved alternate

- B. Installer shall be regularly engaged in the installation of fire alarm systems and shall be factory authorized by the manufacturer to provide sales and service.

PART 2 - PRODUCTS

2.1 SYSTEM OPERATION

- A. Drawings supplied with this specification shall be used by the Contractor as a guide to the required quantities and locations of system equipment. The Contractor shall follow all manufacturer's instructions and provide any additional equipment necessary to provide a complete and operational system meeting the intent of the system design.
- B. The fire alarm system shall be a positive sequence system as defined by NFPA 72. The fire alarm system shall provide both general evacuation and local notification as shown on the Drawings and described herein.
- C. Operation of the fire alarm system in response to an automatic or manual initiating device is described on the Contract Drawings.
- D. Notification devices shall be provided with separate audio and visual circuits such that alarms may be silenced and visual alarms continue to operate until the system is reset.
- E. All initiating, notification and tamper circuits shall be supervised.
- F. Removal of an addressable initiating device shall cause a trouble signal to appear at the Control Panel.

2.2 FIRE ALARM CONTROL PANEL

- A. Main Control Panel: Modular type panel installed in a flush steel cabinet with hinged door and cylinder lock for microprocessor based system. Switches and other controls shall not be accessible without the use of a key. The control panel shall be a neat, compact, factory-wired assembly containing all parts and equipment required to provide specified operating and supervisory functions of the system. Panel cabinet shall be finished on the inside and outside with factory-applied enamel finish. Provide audible trouble signal. Provide indication of: Power on, battery power on, and alarm, trouble and supervisory acknowledge switches. Provide permanent engraved rigid plastic or metal identification plates, or silk-screened labels attached to the rear face of the panel viewing window, for all lamps and switches. System power shall be 120 volts AC services, transformed through a two winding isolation transformer and rectified to 24 volts DC for operation of all system initiating, actuating, signal sounding (indicating appliance), trouble signal and fire alarm tripping circuits. Permanently label all switches. Panel shall be provided with the following features:
 - 1. Trouble silencing switch that transfers audible trouble signals (including remote trouble devices, if provided) to an indicating lamp. For non-self-resetting type switch, upon correction of the trouble condition, audible signals will again sound until the switch is returned to its normal position.
 - 2. Evacuation alarm silencing switch which when activated will silence all alarm indicating appliances without resetting the panel, and cause operation of system trouble signals. Subsequent alarm(s) from additional zone(s) not originally in alarm shall cause activation of the evacuation alarms even with the alarm silencing switch in the "silenced" position.

3. Reset switch when activated will restore the system to normal standby status after the cause of the alarm has been corrected, and all activated initiating devices reset. Operation of reset switch shall restore activated smoke detectors to normal standby status.
4. Lamp test switch.
5. Drill switch which will enable test of alarm devices and restoration to normal without tripping the system.
6. CPU with nonvolatile memory for user defined operating parameters. The system shall be field programmable and configurable from a panel keypad. The system shall remain active and provide fire detection while the program is being edited. The system shall operate in real time for event date and time annotation.
7. Menu driven alpha-numeric liquid crystal display which indicates events stored in the system log, the status of all points, alarm and diagnostic messages.
8. Serial port and two-color, 24 volt Alarm Printer mounted in the Control Panel.
9. Alarm verification, drift compensation and maintenance alert for smoke detectors. Provide dry contact for Owner's use.
10. Custom zone labeling.
11. Dual rate battery charger with volt and ammeters.
12. Maintenance-free sealed recombinant lead-acid type batteries.
13. Transient voltage surge protection. Fire alarm manufacturer shall also provide detailed system grounding instructions to protect the fire alarm system from lightning.
14. Signaling Line Circuits shall be 2-wire, Class A, Style 6. Notification Appliance Circuits shall be 2-wire, Class B, Style W.
15. Remote fire alarm panels may be incorporated into the design where feasible. Provide lightning protection for network wiring.

2.3 DEVICES

A. Manual Pull Stations

1. Dual action, key reset, addressable suitable for semiflush or surface mounting. The device shall be painted red with the word FIRE in white raised letters. Institutional stations shall be key operated only.
2. Each manual fire alarm shall have a nameplate installed permanently on its face indicating its associated address.

B. Area Smoke Detectors

1. Spot type photoelectric analog addressable with integral communications and device identification. Flashing LED indicator for normal operation with steady illumination on alarm. The smoke detector shall measure the analog level of smoke and report the level to the Control Panel. Smoke detectors shall have a sensitivity rating of 2.5%-3% per foot obscuration.
2. Detectors shall be ceiling mounted and shall include twist-lock base.

C. Duct Smoke Detectors

1. Duct smoke detectors shall be photoelectric, analog addressable, with integral communications and device identification. Duct smoke detectors are furnished by the electrical contractor and installed by the mechanical contractor. Control wiring of smoke dampers is by the mechanical contractor. Control wiring of motor shutdown is by the electrical contractor. Wiring to fire alarm panel is by the electrical contractor.
2. All duct detectors shall initiate a supervisory signal to the fire alarm control panel and be provided with 120V rated, form C contacts that open/close upon sensing of smoke or detector failure. Contacts will be used to shut down the associated air handler when detectors are installed in the supply ducts of air handlers. An additional set of form C contacts shall be provided for owners use.
3. Smoke detectors shall have a sensitivity rating of 2.5%-3% per foot obscuration.
4. Smoke detectors located in locked rooms shall be provided with a remote indicating light, indicating the detector address, mounted in the closest open corridor.

D. Heat Detectors

1. Heat detectors shall operate on the combination "rate-of-rise" and "fixed temperature" with the fixed temperature operation with the fixed temperature operation at 140°F or 190°F as required by the physical environment of the room that the device is being installed. The detector shall also include dual thermistor sensing circuitry. Heat detector shall be provided with Flashing LED indicator for normal operation with steady illumination on alarm.
2. Heat detectors shall be ceiling mounted with twist-lock base.
3. Heat detectors located in locked rooms shall be provided with a remote indicating light, indicating detector address, mounted in the closest open corridor.

E. Supervisory Monitoring Modules

1. Provide addressable contact input monitor modules for supervisory status indication for sprinkler system waterflow and tamper switches. Status shall be transmitted to the fire alarm control panel. Monitor modules shall include a mounting plate for installation in a 4" square, 2-1/8" deep junction box.
2. Module shall be provided with flashing LED indicating normal operation of the module.

F. Notification Appliances

1. 24 Volt Xenon Flasher and electronic horns shall be provided as per ADA guidelines. Minimum intensity is 15/75 cd unless otherwise shown on Drawings. Minimum sound levels shall be at least 15dBA above the average ambient sound level or 5 dBA above the maximum sound level in all areas.
2. All visual and audible notification appliances shall be synchronized.

E. Interlocks

Provide addressable relay modules for all interlocks shown on Drawings with contacts rated 120 VAC.

2.4 Universal Digital Alarm Communicator Transmitter (UDACT)

- A. The UDACT shall provide an interface for communicating digital information between the fire alarm panel and a UL-Listed central station. Wire communications between the UDACT and the control panel shall be supervised with one pair for power and one pair for multiplexed communication of overall system status. Systems that utilize relay contacts shall not be considered.
- B. The UDACT shall include connections for dual telephone lines per NFPA/UL/FCC requirements.
- C. The UDACT shall be provided with lightning protection isolating this unit from the control panel.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The Contractor shall provide all equipment and materials required for a fully operational system. The Contractor shall prepare layout drawings showing device locations, raceway size, wiring runs, conduit fill and terminations.
- B. All wiring shall be installed in electrical metallic tubing, galvanized rigid steel conduit or MC cable listed for this use.
- C. All junction boxes and fittings shall be color coded red. Junction Box Covers shall be labeled Fire Alarm System.
- D. Coordinate device locations with other trades to assure proper installation of devices. Coordinate with other trades where work pertains to fire alarm system (i.e. air handling unit control, fire sprinkler system).
- E. The Contractor shall clean all dirt and debris from the inside of the fire alarm control panels, annunciators, devices, etc. and clean the outside of aforementioned equipment after the completion of the installation. During construction, devices and equipment shall have protective coverings to limit amount of dirt and debris.
- F. The manufacturer shall provide on-site supervision of the installation to assure system is installed to meet manufacturers installation requirements.

3.2 TESTING

A. System Acceptance:

1. A pretest shall be held with the installer and the manufacturer's technical representative present. In addition to the requirements listed below, the pretest shall demonstrate that each smoke detector is operative and produces the intended response. Each smoke detector shall be tested in accordance with the manufacturer's recommendations to initiate an alarm at its installed location. After certification of a complete pretest, the installing contractor shall provide the authority having jurisdiction with written documentation from the manufacturer's authorized representative of the outcome of the test and then shall re-inspect in the presence of the authority having jurisdiction and the manufacturer's authorized technical representative. A complete test shall be conducted as follows: the installing contractor, in the presence of a representative of the authority having jurisdiction, shall manually operate every manual fire alarm station, activate every rate of rise type thermodetector with heat, manually operate or electrically short out every fixed temperature thermodetector, actuate every smoke detector with smoke in accordance with the manufacturer's recommendations to demonstrate that smoke can enter the chamber and initiate an alarm, activate every water sprinkler/standpipe flow switch by a flow of water.
2. Each manual fire alarm station, thermodetector, smoke detector, sprinkler system switching circuits, flow switch circuit and each alarm horn/strobe circuit shall be opened in at least two locations to test for the correctness of the supervisory circuitry. All communications shall be tested completely.
3. The fire alarm system may be placed in operation prior to acceptance if in the opinion of the authority having jurisdiction, it will enhance public safety or provide property protection during the final phases of construction. In this case all devices will be thoroughly cleaned or replaced prior to the system acceptance test. The system will not be placed in operation without the written permission of the authority having jurisdiction. Under no circumstances will this be considered a final acceptance test.

- B. The manufacturer's representative shall provide on-site training for the Owner's representatives upon completion of acceptance testing.

END OF SECTION 16700