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SECTION 211313 - FIRE PROTECTION SYSTEMS**PART 1 GENERAL****1.1 RELATED DOCUMENTS**

- A. The provisions of the General Conditions, Supplementary Conditions, Sections included under Division 1, General Requirements, and Section 15050 of this Division are included as a part of this Section as though bound herein.

1.2 SECTION INCLUDES

- A. Piping system.
- B. Wet Pipe Sprinkler System equipment.
- C. Fire department connections.
- D. Indicator valves.
- E. Standpipe/hose valves.

1.3 SUMMARY

- A. The Contractor shall provide the labor, materials, equipment, appliances, services and transportation, and perform operations in connection with the construction and installation of the Work.
- B. Wet Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device.
- C. Extent of the fire protection system is starting 5 FT outside of the **building** fire pump room, all underground piping and valves and devices from the fire pump to all buildings included in this project, **and** all fire sprinkler piping and devices inside of all buildings and by the requirements of this Section.
- D. Work shall be governed by applicable N.F.P.A. codes including N.F.P.A. 24-Private Fire Service Main and Their Appurtenances, FM, UL, the State Fire Marshal, and the local fire department regulations.

1.4 SUBMITTALS

- A. The Contractor shall submit detailed shop drawings for approval for all equipment to be constructed and installed. Such shop drawings shall be complete, giving all required information, and shall be properly checked and coordinated with the work of other trades before submission. No work shall be performed until application shop drawings and layout drawings have been approved by the A/E and Fire Marshall.

- B. Submittals shall consist of:
 - 1. Certification of compliance with sprinkler designer's registration seal.
 - 2. Maintenance drawings.
 - 3. Product drawings.
 - 4. Record drawings.
 - 5. Test reports and certificates due upon completion of work and testing.
 - 6. Submit hydraulic calculations and sprinkler and piping layouts for review prior to submission to the local Fire Marshal.
 - 7. Submit calculations and plans to the local Fire Marshal.

1.5 QUALITY ASSURANCE

- A. Comply with ANSI, NFPA 13, 2010 EDITION, state and local fire codes.
- B. Comply with Factory Mutual "Approval Guide."
- C. Sprinkler heads shall be UL and FM listed and shall be located on spacing requirements as noted in NFPA 13, 2010 EDITION according to the hazard designation.
- D. Provide fire sprinkler piping products which have been approved and labeled by Underwriters Laboratories.
- E. Contractor shall provide to A/E a letter stating compliance with all relevant codes, regulations, standards, and agencies. Also include in the letter the exact location and results of the flow test(s) used to design the system.
- F. The system shall be installed by an experienced firm regularly engaged in the installation of fire suppression systems. The contractor shall provide documentation indicating a minimum of five (5) years experience in design, installation, testing and service of these systems.
- G. The contractor shall provide a list of at least five (5) references for systems similar in nature and size. This will be required to accompany the quotation for information purposes. Failure to supply this information will result in the bidder being considered non-responsive.
- H. The contractor shall be bonded and maintain project and liability insurance. Minimum liability coverage shall not be less than \$2,000,000.00 or 10% of the total installation amount, whichever is greater. Upon receipt of an order, the contractor shall name the Owner as an additionally insured.

1.6 WARRANTY

- A. The components of the Fire Protection System(s) furnished under this division of the specifications shall be guaranteed for a period of one (1) year from the date of acceptance thereof, either for beneficial use or final acceptance, whichever is earlier, against defective materials, design and workmanship. Upon receipt of notice from Architect of failure of any part of the equipment during the guarantee period, the affected part or parts, shall be replaced promptly which includes removing the defective part or parts, replacing and installing the new part or parts and at the expense of the contractor.

1.7 SYSTEM OPERATION

- A. Requirements
 - 1. Existing fire pump and jockey pump shall include components necessary for maintaining a constant discharge pressure during changes in flow and suction pressure.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Acceptable Manufacturers
 - 1. The Reliable Sprinkler Corp.
 - 2. Central Sprinkler Co.
 - 3. Viking Corp.
 - 4. Victaulic

2.2 PIPING SYSTEMS

- A. Aboveground Piping to include schedule 40 black steel and schedule 10 thin wall steel.
- B. All SPRINKLER PIPING subject to the outside conditions shall be galvanized pipe. No exception.
- C. Piping shall be installed from approved hangers and spacing as required per NFPA 13, 2010 EDITION and Specification Section 15060.
- D. Hangers from steel joists must be located at panel points or up to 3 inches on either side of the panel point.
- E. Provide inspection and drain valve and label.
- F. Valves, meters and gauges are to comply with NFPA 13, 2010 EDITION and Specification Sections 15050 and 15100. PRESSURE REDUCING VALVES SHALL BE PROVIDED AT FLOORS WHERE INDICATED ON THE PLANS OR WHERE REQUIRED BY NFPA 14, 2003 EDITION.

2.3 WET PIPE SPRINKLER SYSTEM EQUIPMENT

- A. Provide automatic sprinklers as listed by UL and F.M.
 - 1. Provide brass upright and side wall sprinklers as required on exposed piping in unfinished spaces.
 - 2. Provide chrome recessed pendent sprinkler heads in finished areas such as storage rooms and janitor's closets.
 - 3. Provide white recessed pendent heads with matching escutcheon in all finished areas except as noted on the plans.
 - 4. Center heads in ceiling tile in corridors. All other heads in lay-in ceiling areas shall be in tile to within 1/2" (inch) of grid.
- B. Provide vane type waterflow indicator with electronic retard adjustable up to 90 seconds. Units shall comply with NFPA #72. Provide Potter Electric VSR-F waterflow indicator.
- C. Provide a valve position supervisory switch for monitoring control valve. Provide Potter Electric PCVS or OSYSU-A2 supervisory switch.
- D. Provide a test station for testing alarm systems. Provide control valve test and drain assembly.
- E. Provide grooved check valves and butterfly valves with tamper units in locations as required.

2.4 FIRE DEPARTMENT CONNECTIONS

- A. Fire department siamese connection shall be free standing remote type; **two** three-way connection (2-1/2 inch by 2-1/2 inch 6 4 inch) (2-way); straight **or** angle body; polished chrome body with escutcheon; body inlets complete with individual drop clapper valve and plugs with secure chains; nominal 4-1/2 inch by 12 inch cast brass wall plate with words "CONNECTION TO WET PIPE SPRINKLERS" in 1 inch raised letters; hose connections shall conform to local Fire Department standards.

2.5 INDICATOR VALVE

- A. Indicator valves shall be O.S. & Y. or butterfly. All control valves shall have tamper switches.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install fire protection signs on piping in accordance with ANSI/NFPA 13, 2010 EDITION and ANSI/NFPA 14, 2003 EDITION requirements.
- B. Comply with requirements of ANSI/NFPA 13, 2010 EDITION for installation of fire sprinkler piping materials. Install fire sprinkler piping products where indicated, in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that fire sprinkler piping complies with requirements and serves intended purposes.

- C. Coordinate with other work, including plumbing, HVAC, electrical, etc., as necessary to interface components of fire sprinkler piping properly with other work.
- D. Install supports, anchors, seals, valves, meters, and gauges per NFPA 13, 2010 EDITION and other sections of this specification.
- E. Prior to connecting sprinkler risers for flushing, flush water feed mains, lead-in connections, and control portions of sprinkler piping. After fire sprinkler piping installation has been completed and before piping is placed in service, flush entire sprinkler system, as required to remove foreign substances, under pressure as specified in ANSI/NFPA 13, 2010 EDITION. Continue flushing until water is clear and check to ensure that debris has not clogged sprinklers.
- F. After flushing system, test fire sprinkler piping hydrostatically, for a period of 2 hours, at not less than 200 psi or at 50 psi in excess of maximum static pressure when maximum static pressure is in excess of 150 psi. Check system for leakage of joints. Measure hydrostatic pressure at low point of system.
- G. Repair or replace piping system as required to eliminate leakage in accordance with ANSI/NFPA standards. Retest as specified to demonstrate compliance.
- H. Furnish per NFPA 13, 2010 EDITION additional sprinkler heads for each type of head provided, complete with metal wall cabinet.

3.2 FIELD QUALITY CONTROL

- A. Contractor is responsible for coordinating and witnessing all flow tests with the local water utility.
- B. Flow test shall be taken on the main to which the building supply and the fire protection are to connect. The location of the test shall not exceed a distance of 500 feet from the point of connection. If there are no hydrants on the main to which the building is to connect, the Contractor shall contact the A/E for approval on the nearest alternative location.
- C. In the situation that the building supply is to connect to a main, which is a lateral branch between two mains of equal or greater size, the Contractor shall execute flow tests on both of the other mains. Flow test locations on the two mains are not to exceed a distance of 500 feet from the point of connection to the lateral branch main. A flow test shall also be taken on the lateral branch main to which the building is to connect. Flow test on the lateral branch main shall be executed as per part (B) above.
- D. Flow test(s) shall not be dated earlier than the date of the bid opening. Results obtained by the Contractor are to be forwarded to the A/E within 7 days.

END OF SECTION 211313

SECTION 213113 - ELECTRIC-DRIVE, CENTRIFUGAL FIRE PUMPS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Split-case fire pumps.
 - 2. Fire-pump accessories and specialties.

1.2 PERFORMANCE REQUIREMENTS

- A. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig minimum unless higher pressure rating is indicated.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Certificates: For each fire pump, from manufacturer.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR CENTRIFUGAL FIRE PUMPS

- A. Description: Factory-assembled and -tested, UL Listed, fire-pump and driver unit.
- B. Base: Fabricated and attached to fire-pump and driver unit with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.
- C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

2.2 HORIZONTALLY MOUNTED, SINGLE-STAGE, SPLIT-CASE FIRE PUMPS

- A. Pump:
 - 1. Standard: UL 448, for split-case pumps for fire service.
 - 2. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
 - 3. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
 - 4. Wear Rings: Replaceable bronze.
 - 5. Shaft and Sleeve: Steel shaft with bronze sleeve.
 - a. Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - b. Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
 - 6. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
- B. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
- C. Driver:
 - 1. Standard: UL 1004A
 - 2. Type: Electric motor; NEMA MG 1, polyphase Design B.
- D. Capacities and Characteristics:

1. See plans for Fire Pump Data

2.3 FIRE-PUMP ACCESSORIES AND SPECIALTIES

- A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.
- B. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.
- C. Relief Valves: Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
- D. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.
- E. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.
- F. Hose Valve Manifold Assembly:
 1. Standard: Comply with requirements in NFPA 20.
 2. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
 3. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
 4. Automatic Drain Valve: UL 1726.
 5. Manifold:
 - a. Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
 - b. Body: Brass or ductile iron, with number of outlets required by NFPA 20.
 - c. Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
 - d. Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - e. Escutcheon Plate: Brass or bronze; rectangular.
 - f. Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - g. Exposed Parts Finish: Painted or Brass.
 - h. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

2.4 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
 1. Verification of Performance: Rate fire pumps according to UL 448.
- B. Fire pumps will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment bases and anchorage provisions, with Installer present, for compliance with requirements and for conditions affecting performance of fire pumps.
- B. Examine roughing-in for fire-suppression piping systems to verify actual locations of piping connections before fire-pump installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
- B. Equipment Mounting:
 - 1. Install fire pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in.
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 210548 "Vibration and Seismic for Fire-Suppression Piping and Equipment."
 - 3. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression and Equipment."
- C. Install fire-pump suction and discharge piping equal to sizes required by NFPA 20. Check plans for sizing.
- D. Support piping and pumps separately so weight of piping does not rest on pumps.
- E. Install valves that are same size as connecting piping.
- F. Install pressure gages on fire-pump suction and discharge flange pressure-gage tapings.
- G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.
- H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.
- I. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- J. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup check according to manufacturer's written instructions.

3.3 ALIGNMENT

- A. Align split-case pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
- B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
- C. Align piping connections.
- D. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.

3.4 CONNECTIONS

- A. Comply with requirements for piping and valves specified in NFPA. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps and equipment to allow service and maintenance.
- C. Connect fire pumps to their controllers.

3.5 IDENTIFICATION

- A. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.6 FIELD QUALITY CONTROL

- A. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Section 213900 "Controllers for Fire-Pump Drivers."
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
 - 1. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
 - 2. Test according to NFPA 20 for acceptance and performance testing.

3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.
- 3.7 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 213113

SECTION 213400 - PRESSURE-MAINTENANCE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Vertical-turbine, pressure-maintenance pumps.
- B. Related Section:
 - 1. Section 213900 "Controllers for Fire-Pump Drivers" for pressure-maintenance-pump controllers.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For pumps, accessories, and specialties. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.6 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 VERTICAL-TURBINE, PRESSURE-MAINTENANCE PUMPS

- A. Description: Factory-assembled and -tested, vertical, multistage, open-line-shaft turbine pump as defined in HI 2.1-2.2 and HI 2.3; with pump motor mounted above pump head.
- B. Pump Construction:
 - 1. Pump Head: Cast iron, for surface discharge, with flange, except connections may be threaded in sizes in which flanges are not available.
 - 2. Pump Head Seal: Stuffing box and stuffing.
 - 3. Line Shaft: Stainless steel or steel, with corrosion-resistant shaft sleeves.
 - 4. Line Shaft Bearings: Rubber sleeve, water lubricated.
 - 5. Line Shaft: Steel.
 - 6. Line Shaft Bearings: Corrosion resistant, oil lubricated.
 - 7. Impeller Shaft: Monel metal or stainless steel.
 - 8. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
 - 9. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet (3 m) or less, with strainer of cast or fabricated bronze or stainless steel at bottom.
- C. Motor: Single speed with permanently lubricated ball bearings. Comply with requirements in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."
 - 1. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet (3 m) long. Jockey Pump will be direct wired.
- D. Base: Cast iron or steel with hole for electrical cable.
- E. Nameplate: Permanently attached to pump and indicating capacity and characteristics.
- F. Capacities and Characteristics:
 - 1. See Fire Protection Plans For Jockey Pump

2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 210513 "Common Motor Requirements for Fire Suppression 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.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. NFPA Standard: Comply with NFPA 20 for installation of pressure-maintenance pumps.
- B. Base-Mounted Pump Mounting: Install pumps on concrete bases. Comply with requirements for concrete bases.
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 5. Attach pumps to equipment base using anchor bolts.
- C. Install vertical-turbine, pressure-maintenance pumps according to HI 2.4.

3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Pressure-maintenance pumps will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.3 ADJUSTING

- A. Lubricate pumps as recommended by manufacturer.
- B. Set field-adjustable pressure-switch ranges as indicated.

END OF SECTION 213400

SECTION 213900 - CONTROLLERS FOR FIRE-PUMP DRIVERS**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Full-service, reduced-voltage controllers rated 600 V and less.
2. Limited-service controllers rated 600 V and less.
3. Controllers for diesel-drive fire pumps.
4. Controllers for pressure-maintenance pumps.
5. Remote alarm panels.

1.2 DEFINITIONS

- A. ATS: Automatic transfer switch(es).
- B. ECM: Electronic control module.
- C. MCCB: Molded-case circuit breaker.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each type of product indicated. Include dimensioned plans, elevations, sections, details, and attachments to other work, including required clearances and service spaces around controller enclosures.
 1. Detail equipment assemblies and indicate dimensions, weights, loads, method of field assembly, components, and location and size of each field connection.
 2. Schematic and Connection Diagrams: For power, signal, alarm, and control wiring and for pressure-sensing tubing.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Manufacturer's factory test reports of fully assembled and tested equipment.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

- A. Source Limitations: Obtain fire-pump controllers and all associated equipment from single source or producer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with standards of authorities having jurisdiction pertaining to materials and installation.
- D. Comply with NFPA 20 and NFPA 70.

PART 2 - PRODUCTS

2.1 FULL-SERVICE CONTROLLERS

- A. General Requirements for Full-Service Controllers:
 - 1. Comply with NFPA 20 and UL 218.
 - 2. Listed by an NRTL for electric-motor driver for fire-pump service.
 - 3. Combined automatic and nonautomatic operation.
 - 4. Factory assembled, wired, and tested; continuous-duty rated.
 - 5. Service Equipment Label: NRTL labeled for use as service equipment.
- B. Method of Starting:
 - 1. Pressure-switch actuated.
 - a. Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
 - b. System pressure recorder, electric ac driven, with spring backup.
 - c. Programmable minimum-run-time relay to prevent short cycling.
 - d. Programmable timer for weekly tests.
 - 2. Magnetic Controller: Autotransformer type.
 - 3. Solid-State Controller: Reduced-voltage type.
 - 4. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of all electric or pressure actuators.
- C. Method of Stopping: Automatic and nonautomatic shutdown after automatic starting.
- D. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at controller location.

- E. Method of Isolation and Overcurrent Protection: Interlocked isolating switch and nonthermal MCCB; with a common, externally mounted operating handle, and providing locked-rotor protection.
- F. Door-Mounted Operator Interface and Controls:
 - 1. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
 - 2. Method of Control and Indication:
 - a. Microprocessor-based logic controller, with multiline digital readout.
 - b. Membrane keypad.
 - c. LED alarm and status indicating lights.
 - 3. Local and Remote Alarm and Status Indications:
 - a. Controller power on.
 - b. Motor running condition.
 - c. Loss-of-line power.
 - d. Line-power phase reversal.
 - e. Line-power single-phase condition.
 - 4. Audible alarm, with silence push button.
 - 5. Nonautomatic START and STOP push buttons or switches.
- G. ATS:
 - 1. Complies with NFPA 20, UL 218, and UL 1008.
 - 2. Integral with controller as a listed combination fire-pump controller and power transfer switch.
 - 3. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
 - 4. Allows manual transfer from one source to the other.
 - 5. Alternate-Source Isolating and Disconnecting Means: Integral molded-case switch, with an externally mounted operating handle.
 - 6. Alternate-Source Isolating and Disconnecting Means: Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker shall be provided with nonthermal sensing, instantaneous-only short-circuit overcurrent protection to comply with available fault currents.
 - 7. Local and Remote Alarm and Status Indications:
 - a. Normal source available.
 - b. Alternate source available.
 - c. In normal position.
 - d. In alternate position.
 - e. Isolating means open.
 - 8. Audible alarm, with silence push button.
 - 9. Nonautomatic (manual, nonelectric) means of transfer.
 - 10. Engine test push button.

11. Start generator output contacts.
12. Timer for weekly generator tests.
13. Controller shall have 100,000 A/C Rating.

2.2 CONTROLLERS FOR PRESSURE-MAINTENANCE PUMPS

A. General Requirements for Pressure-Maintenance-Pump Controllers:

1. Type: UL 508 factory assembled, -wired, and tested, across-the-line; for combined automatic and manual operation.
2. Enclosure: UL 508 and NEMA 250, Type 2 for wall-mounting.
3. Factory assembled, wired, and tested.
4. Finish: Manufacturer's standard color paint.

B. Rate controller for scheduled horsepower and include the following:

1. Fusible disconnect switch.
2. Pressure switch.
3. Hand-off-auto selector switch.
4. Pilot light.
5. Running period timer.

C. See Plans for Jockey Dump Data

2.3 REMOTE ALARM PANELS

A. General Requirements for Remote Alarm Panels: Comply with NFPA 20 UL 218; listed by an NRTL for fire-pump service.

B. General Requirements for Remote Alarm Panels: Factory assembled, wired, and tested.

C. Supervisory and Normal Control Voltage: 120-V ac single source.

D. Audible and Visual Alarm and Status Indications:

1. Driver running.
2. Loss of phase.
3. Phase reversal.
4. Supervised power on.
5. Separate trouble on the controller.
6. Controller connected to alternate power source

E. Audible and Visual Alarm and Status Indications: Manufacturer's standard indicating lights; push-to-test.

1. Engine running.
2. Controller main switch turned to the off or manual position.
3. Supervised power on.

4. Separate trouble on the controller or engine.
5. Common pump room trouble
6. Controller connected to alternate power source.

F. Audible alarm, with silence push button.

2.4 ENCLOSURES

- A. Fire-Pump Controllers, ATS, and Remote Alarm Panels: NEMA 250, to comply with environmental conditions at installed locations and NFPA 20.
 1. Indoor, Dry and Clean Locations: Type 1 (IEC IP10).
- B. Enclosure Color: Manufacturer's standard "fire-pump-controller red".
- C. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.
- D. Floor stands, 12 inches (305 mm) high, for floor-mounted controllers.

2.5 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect fire-pump controllers according to requirements in NFPA 20 and UL 218.
 1. Verification of Performance: Rate controllers according to operation of functions and features specified.
- B. Fire-pump controllers will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 CONTROLLER INSTALLATION

- A. Install controllers within sight of their respective drivers.
- B. Connect controllers to their dedicated pressure-sensing lines.
- C. Wall-Mounting Controllers: Install controllers on walls with disconnect operating handles not higher than 79 inches (2006 mm) above finished floor, and bottom of enclosure not less than 12 inches (305 mm) above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

- D. Floor-Mounting Controllers: Install controllers on 4-inch (100-mm) nominal-thickness concrete bases, using floor stands high enough so that the bottom of enclosure cabinet is not less than 12 inches (305 mm) above finished floor. Section 033053 "Miscellaneous Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- F. Comply with NEMA ICS 15.

3.2 REMOTE ALARM PANEL INSTALLATION

- A. Install panels on walls with tops not higher than [72 inches (1829 mm)] <Insert height> above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For panels not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

3.3 POWER WIRING INSTALLATION

- A. Install power wiring between controllers and their services or sources, and between controllers and their drivers. Comply with requirements in NFPA 20, NFPA 70, and Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Comply with NECA 1.

3.4 CONTROL AND ALARM WIRING INSTALLATION

- A. Install wiring between controllers and remote devices. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."
- B. Install wiring between remote alarm panels and controllers. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."
- C. Install wiring between controllers and the building's fire-alarm system. Comply with requirements specified in Section 283111 "Digital, Addressable Fire-Alarm System."
- D. Bundle, train, and support wiring in enclosures.
- E. Connect remote manual and automatic activation devices where applicable.

3.5 IDENTIFICATION

- A. Comply with requirements in NFPA 20 for marking fire-pump controllers.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification in NFPA 20 and as specified in Section 260553 "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Inspect and Test Each Component:
 - a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
 - b. Test insulation resistance for each element, component, connecting supply, feeder, and control circuits.
 - c. Test continuity of each circuit.
 - 2. Verify and Test Each Electric-Driver Controller:
 - a. Verify that voltages at controller locations are within plus 10 or minus 1 percent of motor nameplate rated voltages, with motors off. If outside this range for any motor, notify Engineer of Record before starting the motor(s).
 - b. Test each motor for proper phase rotation.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Field Acceptance Tests:
 - 1. Do not begin field acceptance testing until suction piping has been flushed and hydrostatically tested and the certificate for flushing and testing has been submitted to Fire Protection Engineer of Record and authorities having jurisdiction.
 - 2. Prior to starting, notify authorities having jurisdiction of the time and place of the acceptance testing.
 - 3. Engage manufacturer's factory-authorized service representative to be present during the testing.
 - 4. Perform field acceptance tests as outlined in NFPA 20.
- D. Controllers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. Perform startup service.

- G. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

- A. Adjust controllers to function smoothly and as recommended by manufacturer.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, and timers.
- C. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- D. Set field-adjustable pressure switches.

3.8 DEMONSTRATION

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

END OF SECTION 213900

SECTION 220500 - 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.

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. Mechanical demolition.
 - 9. Equipment installation requirements common to equipment sections.
 - 10. Painting and finishing.
 - 11. Concrete bases.
 - 12. Supports and anchorages.

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. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. 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."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 22 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 22 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, BAg1, 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. ABS Piping: ASTM D 2235.
 - 2. CPVC Piping: ASTM F 493.
 - 3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - 4. PVC to ABS Piping Transition: ASTM D 3138.
- I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

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: CPVC and PVC 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, CPVC PVC CPVC and PVC 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: Carbon steel. 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 waterstop, unless otherwise indicated.
- D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with set screws.
- E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
- F. PVC Pipe: ASTM D 1785, Schedule 40.
- G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

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.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated.
- D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated.
- E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
- F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.
- G. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 MECHANICAL DEMOLITION

- A. Refer to Division 1 Sections "Cutting and Patching" and "Selective Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove mechanical systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - 3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.

4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
 5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 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:
 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type with spring clips.

- d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast-brass type with polished chrome-plated finish.
 - g. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - h. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
 - i. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
- M. Sleeves are not required for core-drilled holes.
- N. Permanent sleeves are not required for holes formed by removable PE sleeves.
- O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
- P. 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.
- Q. 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.

- R. 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.
- S. 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.
- T. Verify final equipment locations for roughing-in.
- U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. 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.
- L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.
- M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.4 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.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install 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.

3.6 PAINTING

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

3.7 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 minimum 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 3.

3.8 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.

3.9 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.

3.10 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 220500

SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT**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. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS**2.1 GENERAL MOTOR REQUIREMENTS**

- A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.
- C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

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

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

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

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

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 220513

SECTION 220519 - METERS AND GAGES FOR 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.

1.2 SUMMARY

- A. This Section includes the following meters and gages for mechanical systems:
 - 1. Thermometers.
 - 2. Gages.
 - 3. Test plugs.
- B. Related Sections include the following:
 - 1. Division 2 Section "Water Distribution" for domestic and fire-protection water service meters outside the building.
 - 2. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.

1.3 DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated; include performance curves.
- B. Shop Drawings: Schedule indicating manufacturer's number, scale range, and location for each.
- C. Product Certificates: For each type of thermometer, gage and flowmeter, signed by product manufacturer.

PART 2 - PRODUCTS**2.1 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

- A. Manufacturers:
 1. Palmer - Wahl Instruments Inc.
 2. Trerice, H. O. Co.
 3. Weiss Instruments, Inc.
 4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Case: Die-cast aluminum or brass, 9 inches long.
- C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.
- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass.
- F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
- H. 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 PLASTIC-CASE, LIQUID-IN-GLASS THERMOMETERS

- A. Manufacturers:
 1. Ernst Gage Co.
 2. Eugene Ernst Products Co.
 3. Marsh Bellofram.
 4. Miljoco Corp.
 5. Trerice, H. O. Co.
 6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
 7. Winters Instruments.
- B. Case: Plastic, 9 inches long.
- C. Tube: Red or blue reading, mercury or organic-liquid filled, with magnifying lens.
- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass or plastic.

- F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- G. Stem: Metal, for thermowell installation and of length to suit installation.
- H. 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:
 - 1. AMETEK, Inc.; U.S. Gauge Div.
 - 2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
 - 3. Palmer - Wahl Instruments Inc.
 - 4. Tel-Tru Manufacturing Company.
 - 5. Trerice, H. O. Co.
 - 6. Weiss Instruments, Inc.
 - 7. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Manufacturers: Same as manufacturer of thermometer being used.
- C. 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. Manufacturers:
 - 1. AMETEK, Inc.; U.S. Gauge Div.
 - 2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
 - 3. Palmer - Wahl Instruments Inc.
 - 4. Trerice, H. O. Co.
 - 5. Weiss Instruments, Inc.
 - 6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
 - 1. Case: Liquid-filled type, drawn steel or cast aluminum 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 metal.
 - 7. Window: Glass.
 - 8. Ring: Metal
 - 9. Accuracy: Grade B, plus or minus 2 percent of middle half scale.
 - 10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
 - 11. Range for Fluids under Pressure: Two times operating pressure.

- C. Remote-Mounting, Dial-Type Pressure Gages: ASME B40.100, indicating-dial type.
 - 1. Case: Dry type, drawn steel or cast aluminum, 6-inch diameter with holes for panel mounting.
 - 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 metal.
 - 7. Window: Glass.
 - 8. Ring: Metal.
 - 9. Accuracy: Grade B, plus or minus 2 percent of middle half scale.
 - 10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure
 - 11. Range for Fluids under Pressure: Two times operating pressure.
- D. Pressure-Gage Fittings:
 - 1. Valves: NPS 1/4 brass or stainless-steel needle type.
 - 2. Syphons: 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.

2.6 TEST PLUGS

- A. Manufacturers:
 - 1. Flow Design, Inc.
 - 2. MG Piping Products Co.
 - 3. National Meter, Inc.
 - 4. Peterson Equipment Co., Inc.
 - 5. Sisco Manufacturing Co.
 - 6. Trerice, H. O. Co.
 - 7. Watts Industries, Inc.; Water Products Div.
- B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.
- C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- D. Core Inserts: One or two self-sealing rubber valves.
 - 1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
 - 2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.
- E. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, two thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
 - 1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be 0 to 200 psig.

2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F.
3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
4. Carrying case shall have formed instrument padding.

2.7 FLOW INDICATORS

- A. Manufacturers:
 1. Brooks Instrument Div.; Emerson Electric Co.
 2. Dwyer Instruments, Inc.
 3. McCrometer, Inc.
 4. OPW Engineered Systems; Dover Corp.
- B. Description: Instrument for installation in piping systems for visual verification of flow.
- C. Construction: Bronze or stainless-steel body; with sight glass and plastic pelton-wheel indicator, and threaded or flanged ends.
- D. Pressure Rating: 125 psig.
- E. Temperature Rating: 200 deg F.
- F. End Connections for NPS 2 and Smaller: Threaded.
- G. End Connections for NPS 2-1/2 and Larger: Flanged.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

- A. Install liquid-in-glass thermometers in the following locations:
 1. Inlet and outlet of each hydronic zone.
 2. Inlet and outlet of each hydronic boiler and chiller.
- B. Install bimetallic-actuated dial thermometers in the following locations:
 1. Inlet and outlet of each zone.
 2. Inlet and outlet of each water heater.
- C. Install liquid-filled-case-type, vapor-actuated dial thermometers at suction and discharge of each pump.
- D. Provide the following temperature ranges for thermometers:
 1. Domestic Hot Water: 30 to 240 deg F, with 2-degree scale divisions.
 2. Domestic Cold Water: 0 to 100 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 test plugs in tees in piping.

3.4 CONNECTIONS

- A. Connect wiring according to Division 16 Section "Conductors and Cables."

3.5 ADJUSTING

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

END OF SECTION 220519

SECTION 220523 - GENERAL-DUTY VALVES FOR 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.

1.2 SUMMARY

- A. This Section includes the following general-duty valves:
 - 1. Copper-alloy ball valves.
 - 2. Ferrous-alloy butterfly valves.
 - 3. Bronze check valves.
 - 4. Ferrous-alloy wafer check valves.
 - 5. Spring-loaded, lift-disc check valves.
 - 6. Resilient-seated, cast-iron, eccentric plug valves.
- B. Related Sections include the following:
 - 1. Division 2 piping Sections for general-duty and specialty valves for site construction piping.
 - 2. Division 22 Section "Plumbing Identification" for valve tags and charts.

1.3 DEFINITIONS

- A. The following are standard abbreviations for valves:
 - 1. CWP: Cold working pressure.
 - 2. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 3. NBR: Acrylonitrile-butadiene rubber.
 - 4. PTFE: Polytetrafluoroethylene plastic.
 - 5. SWP: Steam working pressure.
 - 6. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

- A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.5 QUALITY ASSURANCE

- A. ASME Compliance: ASME B31.9 for building services piping valves.
- B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.
- C. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set ball and plug valves open to minimize exposure of functional surfaces.
 - 4. Set butterfly valves closed or slightly open.
 - 5. Block check valves in either closed or open position.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 VALVES, GENERAL

- A. Refer to Part 3 "Valve Applications" Article for applications of valves.
- B. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.
- C. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.

- D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.
- F. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.
- G. Valve Grooved Ends: AWWA C606.
 - 1. 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.
 - 2. Threaded: With threads according to ASME B1.20.1.
- H. Valve Bypass and Drain Connections: MSS SP-45.

2.3 COPPER-ALLOY BALL VALVES

- A. Available Manufacturers:
- B. Manufacturers:
 - 1. One-Piece, Copper-Alloy Ball Valves:
 - a. American Valve, Inc.
 - b. Crane Co.; Crane Valve Group; Stockham Div.
 - c. Grinnell Corporation.
 - d. Legend Valve & Fitting, Inc.
 - e. NIBCO INC.
 - f. Watts Industries, Inc.; Water Products Div.
 - 2. Two-Piece, Copper-Alloy Ball Valves:
 - a. Crane Co.; Crane Valve Group; Stockham Div.
 - b. Grinnell Corporation.
 - c. Hammond Valve.
 - d. Honeywell Braukmann.
 - e. Legend Valve & Fitting, Inc.
 - f. Milwaukee Valve Company.
 - g. NIBCO INC.
 - h. Red-White Valve Corp.
 - i. Watts Industries, Inc.; Water Products Div.
- C. Copper-Alloy Ball Valves, General: MSS SP-110.
- D. One-Piece, Copper-Alloy Ball Valves: Brass or bronze body with chrome-plated bronze ball, PTFE or TFE seats, and 400-psig minimum CWP rating.

- E. Two-Piece, Copper-Alloy Ball Valves: Bronze body with full -port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.

2.4 FERROUS-ALLOY BUTTERFLY VALVES

- A. Available Manufacturers:

- B. Manufacturers:

- 1. Flangeless, Ferrous-Alloy Butterfly Valves:

- a. American Valve, Inc.
 - b. Crane Co.; Crane Valve Group; Stockham Div.
 - c. Grinnell Corporation.
 - d. Hammond Valve.
 - e. Legend Valve & Fitting, Inc.
 - f. Milwaukee Valve Company.
 - g. NIBCO INC.
 - h. Red-White Valve Corp.
 - i. Watts Industries, Inc.; Water Products Div.

- 2. Flanged, Ferrous-Alloy Butterfly Valves:

- a. Grinnell Corporation.
 - b. Mueller Steam Specialty.

- C. Ferrous-Alloy Butterfly Valves, General: MSS SP-67, Type I, for tight shutoff, with disc and lining suitable for potable water, unless otherwise indicated.

- D. Flangeless, 150-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Wafer type with one -piece stem.

- E. Flanged, 150-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Flanged-end type with one-piece stem.

2.5 BRONZE CHECK VALVES

- A. Available Manufacturers:

- B. Manufacturers:

- 1. Type 1, Bronze, Horizontal Lift Check Valves with Metal Disc:

- a. Crane Co.; Crane Valve Group; Stockham Div.
 - b. Red-White Valve Corp.
 - c. Walworth Co.

- 2. Type 1, Bronze, Vertical Lift Check Valves with Metal Disc:

- a. Crane Co.; Crane Valve Group; Jenkins Valves.
 - b. Red-White Valve Corp.

3. Type 3, Bronze, Swing Check Valves with Metal Disc:

- a. American Valve, Inc.
- b. Crane Co.; Crane Valve Group; Stockham Div.
- c. Grinnell Corporation.
- d. Hammond Valve.
- e. Legend Valve & Fitting, Inc.
- f. Milwaukee Valve Company.
- g. NIBCO INC.
- h. Red-White Valve Corp.
- i. Watts Industries, Inc.; Water Products Div.

C. Bronze Check Valves, General: MSS SP-80.

D. Type 1, Class 150, Bronze, Horizontal Lift Check Valves: Bronze body with bronze disc and seat.

E. Type 1, Class 150, Bronze, Vertical Lift Check Valves: Bronze body with bronze disc and seat.

F. Type 3, Class 150, Bronze, Swing Check Valves: Bronze body with bronze disc and seat.

2.6 FERROUS-ALLOY WAFER CHECK VALVES

A. Available Manufacturers:

B. Manufacturers:

1. Dual-Plate, Ferrous-Alloy, Wafer Check Valves:

- a. Crane Co.; Crane Valve Group; Stockham Div.
- b. Grinnell Corporation.
- c. Mueller Steam Specialty.
- d. NIBCO INC.
- e. Red-White Valve Corp.
- f. Techno Corp.
- g. Watts Industries, Inc.; Water Products Div.

2. Dual-Plate, Ferrous-Alloy, Wafer-Lug Check Valves:

- a. Crane Co.; Crane Valve Group; Crane Valves.
- b. Gulf Valve Co.
- c. Valve and Primer Corp.

C. Ferrous-Alloy Wafer Check Valves, General: API 594, spring loaded.

D. Dual-Plate, Class 125 or 150, Ferrous-Alloy, Wafer Check Valves: Flangeless body.

2.7 SPRING-LOADED, LIFT-DISC CHECK VALVES

A. Available Manufacturers:

B. Manufacturers:

1. Type I, Wafer Lift-Disc Check Valves:
 - a. Mueller Steam Specialty.
 2. Type II, Compact-Wafer, Lift-Disc Check Valves:
 - a. GA Industries, Inc.
 - b. Grinnell Corporation.
 - c. Hammond Valve.
 - d. Milwaukee Valve Company.
 - e. Mueller Steam Specialty.
 - f. NIBCO INC.
 3. Type IV, Threaded Lift-Disc Check Valves:
 - a. Grinnell Corporation.
 - b. Legend Valve & Fitting, Inc.
 - c. Milwaukee Valve Company.
 - d. Mueller Steam Specialty.
 - e. NIBCO INC.
 - f. Watts Industries, Inc.; Water Products Div.
 - C. Lift-Disc Check Valves, General: FCI 74-1, with spring-loaded bronze or alloy disc and bronze or alloy seat.
 - D. Type I, Class 125, Wafer Lift-Disc Check Valves: Wafer style with cast-iron shell with diameter matching companion flanges.
 - E. Type II, Class 125, Compact-Wafer, Lift-Disc Check Valves: Compact-wafer style with cast-iron shell with diameter made to fit within bolt circle.
 - F. Type IV, Class 125, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and threaded ends.
- 2.8 RESILIENT-SEATED, CAST-IRON, ECCENTRIC PLUG VALVES
- A. Available Manufacturers:
 - B. Manufacturers:
 1. General Signal; DeZurik Unit.
 2. Milliken Valve Company.
 3. Olson Technologies; Homestead Div.
 4. Pratt, Henry Company.
 - C. Resilient-Seated, Cast-Iron, Eccentric Plug Valves, NPS 2-1/2 and Smaller: Design similar to MSS SP-108, and rated for 175-psig minimum CWP.
 - D. Resilient-Seated, Cast-Iron, Eccentric Plug Valves, NPS 3 and Larger: MSS SP-108, and rated for 175-psig minimum CWP.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

- A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball, butterfly or plug valves.
 - 2. Throttling Service: Ball or butterfly valves.
 - 3. Pump Discharge: Spring-loaded, lift-disc check valves.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.
- C. Domestic Water Piping: Use the following types of valves:
 - 1. Ball Valves, NPS 2 and Smaller: One -piece, 400-psig CWP rating, copper alloy.
 - 2. Butterfly Valves, NPS 2-1/2 and Larger: Flangeless or Flanged, 150-psig CWP rating, ferrous alloy, with EPDM liner.
 - 3. Lift Check Valves, NPS 2 and Smaller: Type 2, Class 125, horizontal or vertical bronze.
 - 4. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125 bronze.
 - 5. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125 gray iron.
 - 6. Wafer Check Valves, NPS 2-1/2 and Larger: Single, Dual-plate, wafer, wafer-lug double-flanged, Class 125 or 150, ferrous alloy.
 - 7. Spring-Loaded, Lift-Disc Check Valves, NPS 2 and Smaller: Type IV, Class 125 minimum.
 - 8. Spring-Loaded, Lift-Disc Check Valves, NPS 2-1/2 and Larger: Type I or II Class 125 cast iron.
 - 9. Resilient-Seated, Eccentric Plug Valves, NPS 3 and Larger: 175-psig CWP rating, cast iron.
- D. Select valves, except wafer and flangeless types, with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Solder-joint or threaded ends.
2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or threaded ends.
3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or threaded ends.
6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
7. For Grooved-End, Copper Tubing and Steel Piping: Valve ends may be grooved.

3.3 VALVE INSTALLATION

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- C. Locate valves for easy access and provide separate support where necessary.
- D. Install valves in horizontal piping with stem at or above center of pipe.
- E. Install valves in position to allow full stem movement.
- F. Install check valves for proper direction of flow and as follows:
 1. Swing Check Valves: In horizontal position with hinge pin level.
 2. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.
 3. Lift Check Valves: With stem upright and plumb.

3.4 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Basic Materials and Methods" for basic piping joint construction.
- B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- C. 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.

3.5 ADJUSTING

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

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following hangers and supports for mechanical system piping and equipment:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Fastener systems.
 - 5. Equipment supports.
- B. Related Sections include the following:
 - 1. Division 5 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 21 Section "Fire-Suppression Piping" for pipe hangers for fire-protection piping.
 - 3. Division 22 Section "Pipe Expansion Fittings and Loops" for pipe guides and anchors.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 SUBMITTALS

- A. Product Data: For the following:

1. Steel pipe hangers and supports.
 2. Thermal-hanger shield inserts.
 3. Powder-actuated fastener systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
1. Trapeze pipe hangers. Include Product Data for components.
 2. Metal framing systems. Include Product Data for components.
 3. Pipe stands. Include Product Data for components.
 4. Equipment supports.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."
- B. Welding: Qualify procedures and personnel according to the following:
1. AWS D1.1, "Structural Welding Code--Steel."
 2. AWS D1.4, "Structural Welding Code--Reinforcing Steel."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 STEEL PIPE HANGERS AND SUPPORTS

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
- B. Manufacturers:
1. B-Line Systems, Inc.; a division of Cooper Industries.
 2. Globe Pipe Hanger Products, Inc.
 3. Grinnell Corp.
 4. National Pipe Hanger Corporation.
 5. PHD Manufacturing, Inc.

- C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

- A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.
- B. Manufacturers:
 - 1. B-Line Systems, Inc.; a division of Cooper Industries.
 - 2. Power-Strut Div.; Tyco International, Ltd.
 - 3. Thomas & Betts Corporation.
 - 4. Unistrut Corp.; Tyco International, Ltd.
- C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

- A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Manufacturers:
 - 1. PHS Industries, Inc.
 - 2. Pipe Shields, Inc.
 - 3. Value Engineered Products, Inc.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Manufacturers:
 - a. Hilti, Inc.
 - b. ITW Ramset/Red Head.
 - c. Masterset Fastening Systems, Inc.
 - d. Powers Fasteners.
- B. Mechanical-Expansion Anchors: Insert-wedge-type stainless steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Manufacturers:
 - a. B-Line Systems, Inc.; a division of Cooper Industries.
 - b. Hilti, Inc.
 - c. ITW Ramset/Red Head.
 - d. Powers Fasteners.

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 - 2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 6, if little or no insulation is required.
 - 3. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 4. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
 - 5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 - 6. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
 - 7. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
 - 8. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 6.
 - 9. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 10. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 8, from single rod if horizontal movement caused by expansion and contraction might occur.
 - 11. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 8, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 - 12. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 8, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 - 13. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 8, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- F. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 8.
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 8, if longer ends are required for riser clamps.
- G. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 - 2. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 - 3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

- H. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- I. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
- J. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.

5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to 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.
- K. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- L. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- M. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- N. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Steel Pipe Hanger 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. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified 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 D1.1.
- C. Fastener System Installation:
 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

- D. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- E. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- F. 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.
- G. Install lateral bracing with pipe hangers and supports to prevent swaying.
- H. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- I. Load Distribution: Install hangers and supports so 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 (for building services piping) are 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 B31.1 for power piping and ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - 5. Insert Material: Length at least as long as protective shield.
 - 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

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

- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 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 Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 painting Sections.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 220529

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to 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. Pipe markers.
- 5. Stencils.
- 6. Valve tags.
- 7. Valve schedules.
- 8. 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 EQUIPMENT IDENTIFICATION DEVICES

- A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
 - 1. Data:
 - a. Manufacturer, product name, model number, and serial number.
 - b. Capacity, operating and power characteristics, and essential data.
 - c. Labels of tested compliances.
 - 2. Location: Accessible and visible.
 - 3. Fasteners: As required to mount on equipment.
- B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.
 - 1. Terminology: Match schedules as closely as possible.
 - 2. Data:
 - a. Name and plan number.
 - b. Equipment service.
 - c. Design capacity.
 - d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.
 - 3. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.
- C. 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, unless otherwise indicated.
 - 4. Thickness: 1/16 inch for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.
 - 5. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.
- D. Access Panel and Door Markers: 1/16-inch-thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.
 - 1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

- A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
 - 1. Colors: Comply with ASME A13.1, unless otherwise indicated.
 - 2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
 - 3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
 - 4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type 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. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.
- C. Shaped Pipe Markers: Preformed semirigid 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 thick with pressure-sensitive, permanent-type, self-adhesive back.
 - 1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
 - 2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

2.3 STENCILS

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

2.4 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by Architect <Insert other>. Provide 5/32-inch hole for fastener.
 - 1. Material: 0.032-inch- thick aluminum.
 - 2. Material: 0.0375-inch- thick stainless steel.
 - 3. Material: 3/32-inch- thick laminated plastic with 2 black surfaces and white inner layer.

4. Valve-Tag Fasteners: Brass wire-link or beaded chain; or S-hook VALVE SCHEDULES
 - B. 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.
- 2.5 WARNING TAGS
- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.
 1. Size: Approximately 4 by 7 inches Fasteners: Brass grommet and wire.
 2. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
 3. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

- A. Products specified are for applications referenced in other Division 22 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. Pumps, compressors, chillers, condensers, and similar motor-driven units.
 2. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
 3. 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 for name of units if viewing distance is less than 24 inches 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater

- viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- 2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
- 3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
 - a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
 - b. Fire department hose valves and hose stations.
 - c. Meters, gages, thermometers, and similar units.
 - d. Pumps, compressors, condensers, and similar motor-driven units.
 - e. Heat exchangers, coils, evaporators, and similar equipment.
 - f. Packaged HVAC central-station and zone-type units.
- 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 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. Orange: For combination cooling and heating equipment and components.
 - 2. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 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. Pumps, compressors, condensers, and similar motor-driven units.
 - c. Heat exchangers, coils, evaporators, and similar equipment.
 - d. Packaged HVAC central-station and zone-type units.
- 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 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: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 3/4 inch 1-1/2 inches wide, lapped at least 1-1/2 inches at both ends of pipe marker, and covering full circumference of pipe.
 - 2. Pipes with OD, Including Insulation, 6 Inches and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 3 inches at both ends of pipe marker, and covering full circumference of pipe.
- B. Stenciled Pipe Marker Option: Stenciled markers may be provided instead of manufactured pipe markers, at Installer's option. Install stenciled pipe markers 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 nonconcealed 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 nonaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

3.4 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:
 - 1. Valve-Tag Size and Shape:
 - a. Cold Water: 1-1/2 inches, 2 inches, round square.
 - b. Hot Water: 1-1/2 inches, 2 inches, round square.
 - c. Fire Protection: 1-1/2 inches, 2 inches, round square.
 - d. Gas: 1-1/2 inches, 2 inches, round square.
 - e. Steam: 1-1/2 inches, 2 inches, round square.

2. Valve-Tag Color:
 - a. Cold Water: Green.
 - b. Fire Protection: Red
 - c. Gas: Yellow
3. Letter Color:
 - a. Cold Water: White.
 - b. Fire Protection: White.
 - c. Gas: White.

3.5 VALVE-SCHEDULE INSTALLATION

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

3.6 WARNING-TAG INSTALLATION

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

3.7 ADJUSTING

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

3.8 CLEANING

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

END SECTION 220553

SECTION 220700 - PLUMBING INSULATION**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Insulation Materials:
 - a. Cellular glass.
 - b. Flexible elastomeric.
 - 2. Insulating cements.
 - 3. Adhesives.
 - 4. Mastics.
 - 5. Lagging adhesives.
 - 6. Sealants.
 - 7. Factory-applied jackets.
 - 8. Field-applied fabric-reinforcing mesh.
 - 9. Field-applied cloths.
 - 10. Field-applied jackets.
 - 11. Tapes.
 - 12. Securements.
 - 13. Corner angles.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).
- B. Shop Drawings:
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 3. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 4. Detail application of field-applied jackets.
 - 5. Detail field application for each equipment type.

- C. Remaining paragraphs are defined in Division 01 Section "Submittal Procedures" as "Informational Submittals."
- D. Qualification Data: For qualified Installer.
- E. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- F. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cell-U-Foam Corporation; Ultra-CUF.
 - b. Pittsburgh Corning Corporation; Foamglas Super K.
 - 2. Block Insulation: ASTM C 552, Type I.
 - 3. Special-Shaped Insulation: ASTM C 552, Type III.
 - 4. Board Insulation: ASTM C 552, Type IV.
 - 5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
 - 6. Preformed Pipe Insulation with Factory-Applied ASJ or ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
- G. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Aeroflex USA Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

2.2 ADHESIVES

- A. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-96.
 - b. Foster Products Corporation, H. B. Fuller Company; 81-33.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Aeroflex USA Inc.; Aeroseal.
 - b. Armacell LCC; 520 Adhesive.
 - c. Foster Products Corporation, H. B. Fuller Company; 85-75.
 - d. RBX Corporation; Rubatex Contact Adhesive.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- D. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Dow Chemical Company (The); 739, Dow Silicone.
 - b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Speedline Corporation; Speedline Vinyl Adhesive.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 MASTICS

- A. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-35.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-90.
 - c. ITW TACC, Division of Illinois Tool Works; CB-50.
 - d. Marathon Industries, Inc.; 590.
 - e. Mon-Eco Industries, Inc.; 55-40.
 - f. Vimasco Corporation; 749.
 2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 5. Color: White.
- B. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-30.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-35.
 - c. ITW TACC, Division of Illinois Tool Works; CB-25.
 - d. Marathon Industries, Inc.; 501.
 - e. Mon-Eco Industries, Inc.; 55-10.
 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
 3. Service Temperature Range: 0 to 180 deg F.
 4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 5. Color: White.
- C. Description: Shall be compatible with insulation materials, jackets, and substrates.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-52.
 - b. Foster Products Corporation, H. B. Fuller Company; 81-42.
 - c. Marathon Industries, Inc.; 130.
 - d. Mon-Eco Industries, Inc.; 11-30.
 - e. Vimasco Corporation; 136.
 2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
 3. Service Temperature Range: Minus 50 to plus 180 deg F.
 4. Color: White.

2.4 SEALANTS

- A. Joint Sealants:

1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-76.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-45.
 - c. Marathon Industries, Inc.; 405.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Pittsburgh Corning Corporation; Pittseal 444.
 - f. Vimasco Corporation; 750.
2. Joint Sealants for Polystyrene Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-70.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-45/30-46.
 - c. Marathon Industries, Inc.; 405.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Vimasco Corporation; 750.
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 deg F.
6. Color: White or gray.
7. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
 4. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
 - a. Products: Subject to compliance with requirements, provide the following:
 - 1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 5. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
 - a. Products: Subject to compliance with requirements, provide the following:

- 1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 6. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
 - a. Products: Subject to compliance with requirements, provide the following:
 - 1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
- 2.6 FIELD-APPLIED FABRIC-REINFORCING MESH
 - A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.
 1. Products: Subject to compliance with requirements, provide the following:
 - a. Vimasco Corporation; Elastafab 894.
 - B. Woven Glass-Fiber Fabric for Equipment Insulation: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.
 1. Products: Subject to compliance with requirements, provide the following:
 - a. Childers Products, Division of ITW; Chil-Glas No. 5.
- 2.7 FIELD-APPLIED JACKETS
 - A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
 - B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto PVC Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: White Color-code jackets based on system.
 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 5. Factory-fabricated tank heads and tank side panels.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
 - b. Compac Corp.; 104 and 105.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 2. Width: 3 inches.
 3. Thickness: 11.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - b. Compac Corp.; 110 and 111.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
 - d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
 2. Width: 3 inches.
 3. Thickness: 6.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
 - b. Compac Corp.; 130.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
 - d. Venture Tape; 1506 CW NS.
 2. Width: 2 inches.
 3. Thickness: 6 mils.
 4. Adhesion: 64 ounces force/inch in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch in width.

2.9 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

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.
 - 1. Verify that systems and equipment to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
 - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.

- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Division 07 Section "Penetration Firestopping".
- F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

- A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
 2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 3. Protect exposed corners with secured corner angles.
 4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

- a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
 - d. Do not overcompress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
 6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
 7. Stagger joints between insulation layers at least 3 inches.
 8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
 9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
 10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
- B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 2. Seal longitudinal seams and end joints.

3.6 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against

- adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on

- each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

- #### A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- #### B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.10 FINISHES

A. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

- a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.11 EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
- C. Domestic water storage tank insulation shall be one of the following:
 - 1. Cellular Glass: 2 inches thick.
 - 2. Flexible Elastomeric: 1 inch thick.

3.12 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.
 - 2. Underground piping.
 - 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.13 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Hot and Recirculated Hot Water:
 - 1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 3/4 inch 1 inch thick.
 - 2. NPS 1-1/2 and Larger: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 1 inch thick.
- B. Stormwater and Overflow:

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 1 inch thick.
- C. Roof Drain and Overflow Drain Bodies:
 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 1 inch thick.
- D. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
 - c. Polyolefin: 1 inch thick.
- E. Condensate and Equipment Drain Water below 60 Deg F:
 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 3/4 inch 1 inch thick.
- F. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:
 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 3/4 inch 1 inch thick.
- G. Hot Service Drains:
 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches thick.

END OF SECTION 220700

SECTION 221116 - DOMESTIC WATER 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.

1.2 SUMMARY

- A. This Section includes domestic water piping inside the building.
- B. Water meters will be furnished and installed by utility company.
- C. Related Sections include the following:
 - 1. Division 2 Section "Water Distribution" for water-service piping outside the building from source to the point where water-service piping enters the building.
 - 2. Division 22 Section "Meters and Gages" for thermometers, pressure gages, and fittings.
 - 3. Division 22 Section "Plumbing Specialties" for water distribution piping specialties.

1.3 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing domestic water piping systems with 80 psig, unless otherwise indicated.

1.4 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Water Samples: Specified in Part 3 "Cleaning" Article.
- C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14, "Plastics Piping System Components and Related Materials," for plastic, potable domestic water piping and components. Include marking "NSF-pw" on piping.
- C. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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 COPPER TUBE AND FITTINGS

- A. Piping 4" and smaller - Hard Copper Tube: ASTM B 88, Types L (ASTM B 88M, Types B), 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.

2.4 PEX TUBE AND FITTINGS

- A. PEX Distribution System: ASTM F 877, SDR 9 tubing.
- B. Fittings for PEX Tube: ASTM F 1807, metal-insert type with copper or stainless-steel crimp rings and matching PEX tube dimensions.
- C. Manifold: Multiple-outlet, plastic or corrosion-resistant-metal assembly complying with ASTM F 877; with plastic or corrosion-resistant-metal valve for each outlet.

2.5 PEX-AL-PEX TUBE AND FITTINGS

- A. PEX-AL-PEX Distribution System: ASTM F 1281 tubing.

- B. Fittings for PEX-AL-PEX Tube: ASTM F 1281, metal-insert type with copper or stainless-steel crimp rings and matching PEX-AL-PEX tube dimensions.

2.6 PEX-AL-HDPE TUBE AND FITTINGS

- A. PEX-AL-HDPE Distribution System: ASTM F 1986 tubing.
- B. Fittings for PEX-AL-HDPE Tube: ASTM F 1986, metal-insert type with copper or stainless-steel crimp ring and matching PEX-AL-HDPE tube dimensions.

2.7 CPVC PIPING

- A. CPVC Pipe: ASTM F 441/F 441M, Schedule 40 and Schedule 80.
 - 1. CPVC Socket Fittings: ASTM F 438 for Schedule 40 and ASTM F 439 for Schedule 80.
 - 2. CPVC Threaded Fittings: ASTM F 437, Schedule 80.
- B. CPVC Piping System: ASTM D 2846/D 2846M, SDR 11, pipe and socket fittings.
- C. CPVC Tubing System: ASTM D 2846/D 2846M, SDR 11, tube and socket fittings.

2.8 STAINLESS STEEL PIPING

- A. Type 304 stainless steel socket weld or threaded end fittings. ANSI 1 B16.3, B16.5.

2.9 VALVES

- A. Bronze and cast-iron, general-duty valves are specified in Division 22 Section "Valves."
- A. Balancing and drain valves are specified in Division 22 Section "Plumbing Specialties."

2.10 PIPING JOINING MATERIALS

- A. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.
 - 1. Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.11 SPECIALTY VALVES

- A. Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty metal valves.
- B. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.
- C. CPVC Union Ball Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Asahi/America, Inc.
 - c. Colonial Engineering, Inc.
 - d. Fischer, George Inc.
 - e. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
 - f. IPEX Inc.
 - g. NIBCO INC.
 - h. Sloane, George Fischer, Inc.
 - i. Spears Manufacturing Company.
 - j. Thermoplastic Valves Inc.
 - 2. Description:
 - a. Standard: MSS SP-122.
 - b. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
 - c. Body Material: CPVC.
 - d. Body Design: Union type.
 - e. End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket or threaded.
 - f. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket or threaded.
 - g. Ball: CPVC; full port.
 - h. Seals: PTFE or EPDM-rubber O-rings.
 - i. Handle: Tee shaped.
- D. CPVC Non-Union Ball Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Asahi/America, Inc.
 - c. King Bros. Industries.
 - d. Legend Valve.
 - e. NIBCO INC.
 - f. Spears Manufacturing Company.
 - g. Thermoplastic Valves Inc.
 - 2. Description:

- a. Standard: MSS SP-122.
- b. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
- c. Body Material: CPVC.
- d. Body Design: Non-union type.
- e. End Connections: Socket or threaded.
- f. Ball: CPVC; full or reduced port.
- g. Seals: PTFE or EPDM-rubber O-rings.
- h. Handle: Tee shaped.

E. CPVC Butterfly Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fischer, George Inc.
 - b. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
 - c. NIBCO INC.
 - d. Sloane, George Fischer, Inc.
 - e. Spears Manufacturing Company.
 - f. Thermoplastic Valves Inc.
- 2. Description:
 - a. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
 - b. Body Material: CPVC.
 - c. Body Design: Lug or wafer type.
 - d. Seat: EPDM rubber.
 - e. Seals: PTFE or EPDM-rubber O-rings.
 - f. Disc: CPVC.
 - g. Stem: Stainless steel.
 - h. Handle: Lever.

F. CPVC Ball Check Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Asahi/America, Inc.
 - c. Colonial Engineering, Inc.
 - d. Fischer, George Inc.
 - e. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
 - f. IPEX Inc.
 - g. NIBCO INC.
 - h. Sloane, George Fischer, Inc.
 - i. Spears Manufacturing Company.
 - j. Thermoplastic Valves Inc.
- 2. Description:
 - a. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
 - b. Body Material: CPVC.

- c. Body Design: Union-type ball check.
- d. End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket or threaded.
- e. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket or threaded.
- f. Ball: CPVC.
- g. Seals: EPDM- or FKM-rubber O-rings.

G. CPVC Gate Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Sloane, George Fischer, Inc.
 - b. Spears Manufacturing Company.
- 2. Description:
 - a. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
 - b. Body Material: CPVC.
 - c. Body Design: Nonrising stem.
 - d. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or Threaded.
 - e. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Socket or threaded.
 - f. Gate and Stem: Plastic.
 - g. Seals: EPDM rubber.
 - h. Handle: Wheel.

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Excavating, trenching, and backfilling are specified in Division 2 Section "Earthwork."

3.2 PIPE AND FITTING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
- B. Flanges may be used on aboveground piping, unless otherwise indicated.
- C. Grooved joints may be used on aboveground grooved-end piping.
- D. Domestic Water Piping on Service Side of Water Meter inside the Building: Use any of the following piping materials for each size range:
 - 1. NPS 4 to NPS 6: Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.
- E. Under-Building-Slab, Domestic Water Piping on House Side of Water Meter, NPS 4 and Smaller: Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.

- F. Aboveground Domestic Water Piping: Use any of the following piping materials for each size range:
 - 1. NPS 4 and Smaller: Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.
 - 2. NPS 4: Type 304 stainless steel socket weld or threaded end fittings.
- G. Pipe Fittings, 4" and smaller – Above ground installation
 - 1. Wrought Copper, ANSI B16.22.

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 stainless steel ball valves for piping NPS 2 and smaller. Use cast-iron butterfly or gate valves with flanged ends for piping NPS 2-1/2 and larger.
 - 2. Throttling Duty: Use bronze ball or globe valves for piping NPS 2 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 and larger.
 - 3. Hot-Water-Piping, Balancing Duty: Calibrated balancing valves.
 - 4. Drain Duty: Hose-end drain valves.
- B. 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 valves for piping NPS 2 and smaller. Use butterfly valves for piping NPS 2-1/2 and larger.
- C. 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.
- D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 and smaller and butterfly valves for piping NPS 2-1/2 and larger. Balancing valves are specified in Division 22 Section "Plumbing Specialties."
- E. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Calibrated balancing valves are specified in Division 22 Section "Plumbing Specialties."

3.4 PIPING INSTALLATION

- A. Basic piping installation requirements are specified in Division 22 Section "Basic Materials and Methods."
- B. Install under-building-slab copper tubing according to CDA's "Copper Tube Handbook."

- C. Install galvanized steel sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Basic Materials and Methods."
- D. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Wall penetration systems are specified in Division 22 Section "Basic Materials and Methods."
- E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Pressure gages are specified in Division 22 Section "Plumbing Specialties."
- F. Install water-pressure regulators downstream from shutoff valves. Water-pressure regulators are specified in Division 22 Section "Plumbing Specialties."
- G. Install domestic water piping level without pitch and plumb.
- H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

3.5 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section "Basic Materials and Methods."
- B. 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.
- C. 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. Apply primer.
 - 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3. PVC Piping: Join according to ASTM D 2855.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Pipe hanger and support devices are specified in Division 22 Section "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 and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet : MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet : MSS Type 49, spring cushion rolls, if indicated.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet 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 22 Section "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.
- E. Install vinyl-coated hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1 (DN 25) and Smaller: 36 inches (900 mm) with 3/8-inch (10-mm) rod.
 - 2. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
 - 3. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
 - 4. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
 - 5. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
 - 6. NPS 8 (DN 200): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.
- F. Install supports for vertical CPVC piping every 60 inches (1500 mm) for NPS 1 (DN 25) and smaller, and every 72 inches (1800 mm) for NPS 1-1/4 (DN 32) and larger.
- G. Install vinyl-coated hangers for PEX piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1 (DN 25) and Smaller: 32 inches (815 mm) with 3/8-inch (10-mm) rod.
- H. Install hangers for vertical PEX piping every 48 inches (1200 mm).
- I. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.
- J. 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.
 - 6. NPS 4 and NPS 5 : 12 feet with 5/8-inch rod.
 - 7. NPS 6 : 12 feet with 3/4-inch rod.
- K. Install supports for vertical steel piping every 15 feet.
- L. 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.
 - 6. NPS 6 : 10 feet with 5/8-inch rod.

7. NPS 8: 10 feet with 3/4-inch rod.

M. Install supports for vertical copper tubing every 10 feet .

N. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.8 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 water-service piping with shutoff valve, and extend and connect to the following:

1. Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water supply and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Plumbing Fixtures."
4. 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.

3.9 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, domestic water, building-service piping, 2" and smaller, shall be the following:

1. CPVC, Schedule 40 pipe socket fittings; and solvent-cemented joints.

D. Under-building-slab, domestic water piping, 2 1/2" and larger, shall be the following:

1. CPVC, Schedule 80 pipe socket fittings; and solvent-cemented joints.

E. Aboveground domestic water piping, 2" and smaller, shall be the following:

1. CPVC, Schedule 40 pipe; socket fittings; and solvent-cemented joints.
2. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
3. CPVC Tubing System: CPVC tube; CPVC socket fittings; and solvent-cemented joints. CPVC pipe with CPVC socket fittings may be used instead of tubing.
4. PEX Tube; fittings for PEX tube; and crimped or cold-expansion joints.

F. Aboveground domestic water piping, 2 1/2" and larger, shall be the following:

1. CPVC, Schedule 80 pipe socket fittings; and solvent-cemented joints.
2. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.

3.10 VALVE SCHEDULE

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 butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 (DN 50) and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves or CircuitSolver.
4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

D. CPVC valves matching piping materials may be used.

3.11 FIELD QUALITY CONTROL

A. Portions of testing and inspection requirements in this Article are taken from model plumbing codes. Edit if requirements vary.

B. 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.

C. 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.

3.12 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. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
 - b. Adjust calibrated balancing valves to provide flow of hot water in all branches.
5. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.13 CLEANING

A. Clean and disinfect 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.
- B. Prepare and submit reports of purging and disinfecting activities.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING 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.

1.2 SUMMARY

- A. This Section includes the following domestic water piping specialties:

- 1. Vacuum breakers.
- 2. Backflow preventers.
- 3. Water pressure-reducing valves.
- 4. Balancing valves.
- 5. Temperature-actuated water mixing valves.
- 6. Strainers.
- 7. Hose bibbs.
- 8. Wall hydrants.
- 9. Water hammer arresters.
- 10. Trap-seal primer valves.
- 11. Trap-seal primer systems.

1.3 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

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. NSF Compliance:
 - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 - 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
 - 1. 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:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Co.
 - b. FEBCO; SPX Valves & Controls.
 - c. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Wilkins Div.
 - 3. Standard: ASSE 1001.
 - 4. Size: NPS 1/4 to NPS 3, as required to match connected piping.
 - 5. Body: Bronze.
 - 6. Inlet and Outlet Connections: Threaded.
 - 7. Finish: Chrome plated.
- B. Hose-Connection Vacuum Breakers:
 - 1. 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:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Legend Valve.
 - b. Watts Industries, Inc.; Water Products Div.
 - c. Woodford Manufacturing Company.
 - d. Zurn Plumbing Products Group; Wilkins Div.
 - 3. Standard: ASSE 1011.
 - 4. Body: Bronze, nonremovable, with manual drain.

5. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
6. Finish: Chrome or nickel plated.

C. Pressure Vacuum Breakers:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Ames Co.
 - b. FEBCO; SPX Valves & Controls.
 - c. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Wilkins Div.
4. Standard: ASSE 1020.
5. Operation: Continuous-pressure applications.
6. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
7. Accessories:
 - a. Valves: Ball type, on inlet and outlet.

2.2 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. FEBCO; SPX Valves & Controls.
 - b. Legend Valve.
 - c. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Wilkins Div.
3. Standard: ASSE 1012.
4. Operation: Continuous-pressure applications.
5. Size: [NPS 1/2 (DN 15)] [NPS 3/4 (DN 20)].
6. Body: Bronze.
7. End Connections: Union, solder joint.
8. Finish: Rough bronze.

B. Reduced-Pressure-Principle Backflow Preventers:

1. 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:

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. FEBCO; SPX Valves & Controls.
 - b. Watts Industries, Inc.; Water Products Div.
 - c. Zurn Plumbing Products Group; Wilkins Div.
 4. Standard: ASSE 1013.
 5. Operation: Continuous-pressure applications.
 6. Pressure Loss: 8 psig maximum, through middle 1/3 of flow range.
 7. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
 8. End Connections: Threaded for NPS 2 and smaller; [flanged] <Insert type> for NPS 2-1/2 and larger.
 9. Configuration: Designed for horizontal center section, and vertical outlet flow.
 10. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.
- C. Double-Check Backflow-Prevention Assemblies:
1. 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:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. FEBCO; SPX Valves & Controls.
 - b. Watts Industries, Inc.; Water Products Div.
 - c. Zurn Plumbing Products Group; Wilkins Div.
 4. Standard: ASSE 1015.
 5. Operation: Continuous-pressure applications, unless otherwise indicated.
 6. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
 7. Size: as indicated on plans
 8. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
 9. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
 10. Configuration: Designed for horizontal, straight through flow.
 11. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

D. Dual-Check-Valve Backflow Preventers:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. FEBCO; SPX Valves & Controls.
 - b. Honeywell Water Controls.
 - c. Legend Valve.
 - d. Mueller Co.; Water Products Div.
 - e. Watts Industries, Inc.; Water Products Div.
 - f. Zurn Plumbing Products Group; Wilkins Div.
3. Standard: ASSE 1024.
4. Operation: Continuous-pressure applications.
5. Body: Bronze with union inlet.

E. Double-Check, Detector-Assembly Backflow Preventers:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. FEBCO; SPX Valves & Controls.
 - b. Watts Industries, Inc.; Water Products Div.
 - c. Zurn Plumbing Products Group; Wilkins Div.
4. Standard: ASSE 1048 and FMG approved or UL listed.
5. Operation: Continuous-pressure applications.
6. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
7. Size: as indicated on plans.
8. Body: Cast iron with interior lining complying with AWWA C550 or that is FDA approved
9. End Connections: Flanged.
10. Configuration: Designed for horizontal, straight through flow.
11. Accessories:
 - a. Valves: Outside screw and yoke gate-type with flanged ends on inlet and outlet.
 - b. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

F. Backflow-Preventer Test Kits:

1. 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:

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. FEBCO; SPX Valves & Controls.
 - b. Watts Industries, Inc.; Water Products Div.
 - c. Zurn Plumbing Products Group; Wilkins Div.
4. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.3 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Honeywell Water Controls.
 - b. Watts Industries, Inc.; Water Products Div.
 - c. Zurn Plumbing Products Group; Wilkins Div.
3. Standard: ASSE 1003.
4. Pressure Rating: Initial working pressure of 150 psig (1035 kPa).
5. Size: as indicated on plans
6. Design Flow Rate: see schedule on plans
7. Design Inlet Pressure: see schedule on plans
8. Design Outlet Pressure Setting: see schedule on plans
9. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.4 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Armstrong International, Inc.
 - b. ITT Industries; Bell & Gossett Div.

- c. NIBCO INC.
 - d. Taco, Inc.
 - e. Watts Industries, Inc.; Water Products Div.
 - 4. Type: Ball valve with two readout ports and memory setting indicator.
 - 5. Body: Brass.
 - 6. Size: Same as connected piping, but not larger than NPS 2.
 - 7. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.
- B. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.
- C. Memory-Stop Balancing Valves:
- 1. 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:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Jenkins Valves.
 - b. Crane Co.; Crane Valve Group; Stockham Div.
 - c. Hammond Valve.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Red-White Valve Corp.
 - 3. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
 - 4. Pressure Rating: 400-psig minimum CWP.
 - 5. Size: NPS 2 or smaller.
 - 6. Body: Copper alloy.
 - 7. Port: Standard or full port.
 - 8. Ball: Chrome-plated brass.
 - 9. Seats and Seals: Replaceable.
 - 10. End Connections: Solder joint or threaded.
 - 11. Handle: Vinyl-covered steel with memory-setting device.

2.5 TEMPERATURE-ACTUATED WATER MIXING VALVES

- A. Water-Temperature Limiting Devices:
- 1. 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:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Armstrong International, Inc.
 - b. Honeywell Water Controls.
 - c. Leonard Valve Company.

- d. Powers; a Watts Industries Co.
 - e. Symmons Industries, Inc.
 - f. Watts Industries, Inc.; Water Products Div.
- 4. Standard: ASSE 1017.
 - 5. Pressure Rating: 125 psig.
 - 6. Type: Thermostatically controlled water mixing valve.
 - 7. Material: Bronze body with corrosion-resistant interior components.
 - 8. Connections: Threaded union inlets and outlet.
 - 9. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
 - 10. Tempered-Water Setting: 120 degrees F.
 - 11. Valve Finish: Rough bronze.

2.6 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

- 1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
- 2. Body: Bronze for NPS 2 and smaller; cast iron FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
- 3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
- 4. Screen: Stainless steel with round perforations, unless otherwise indicated.
- 5. Perforation Size:
 - a. Strainers NPS 2 and Smaller: 0.020 inch.
 - b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
 - c. Strainers NPS 5 (DN 125) and Larger: 0.10 inch.
- 6. Drain: Factory-installed, hose-end drain valve.

2.7 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

- 1. 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:
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. PPP Inc.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
- 3. Standard: ASSE 1010 or PDI-WH 201.
- 4. Type: Copper tube with piston.
- 5. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.8 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. PPP Inc.
 - b. Sioux Chief Manufacturing Company, Inc.
 - c. Watts Industries, Inc.; Water Products Div.
3. Standard: ASSE 1018.
4. Pressure Rating: 125 psig minimum.
5. Body: Bronze.
6. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
7. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
8. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

B. Drainage-Type, Trap-Seal Primer Valves:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
3. Standard: ASSE 1044, lavatory P-trap with NPS 3/8 minimum, trap makeup connection.
4. Size: NPS 1-1/4 minimum.
5. Material: Chrome-plated, cast brass.

2.9 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. PPP Inc.
4. Standard: ASSE 1044,

5. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.
6. Cabinet: Recessed-mounting steel box with stainless-steel cover.
7. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.
8. Vacuum Breaker: ASSE 1001.
9. Number Outlets: Four.
10. Size Outlets: NPS 1/2.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Basic Materials and Methods" for piping joining materials, joint construction, and basic installation requirements.
- B. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.
- C. Install balancing valves in locations where they can easily be adjusted.
- D. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
 1. Install thermometers and water regulators if specified.
 2. Install cabinet-type units recessed in or surface mounted on wall as specified.
- E. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 6 Section "Rough Carpentry."
- F. Install hose stations with check stops or shutoff valves on inlets and with thermometer on outlet.
 1. Install shutoff valve on outlet if specified.
 2. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 6 Section "Rough Carpentry."
- G. Install nonfreeze, nondraining-type post hydrants set in concrete or pavement.
- H. Install water hammer arresters in water piping according to PDI-WH 201.
- I. Install supply-type, 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.
- J. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding."
- C. Connect wiring according to Division 26 Section "Conductors and Cables."

3.3 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 - 1. Pressure vacuum breakers.
 - 2. Reduced-pressure-principle backflow preventers.
 - 3. Double-check backflow-prevention assemblies.
 - 4. Dual-check-valve backflow preventers.
 - 5. Double-check, detector-assembly backflow preventers.
 - 6. Water pressure-reducing valves.
 - 7. Calibrated balancing valves.
 - 8. Primary, thermostatic, water mixing valves.
 - 9. Hose stations.
 - 10. Supply-type, trap-seal primer valves.
 - 11. Trap-seal primer systems.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and prepare test reports:
 - 1. Test each pressure vacuum breaker according to authorities having jurisdiction and the device's reference standard.
- B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.5 ADJUSTING

- A. Set field-adjustable pressure set points of water pressure-reducing valves.
- B. Set field-adjustable flow set points of balancing valves.
- C. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION 221119

SECTION 221316 - SANITARY WASTE AND VENT 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.

1.2 SUMMARY

- A. This Section includes the following for soil, waste, and vent piping inside the building:
 - 1. Pipe, tube, and fittings.
 - 2. Special pipe fittings.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. PVC: Polyvinyl chloride plastic.
- C. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10-foot head of water.

1.5 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Shop Drawings:
 - 1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.
- C. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

- B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPING MATERIALS

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

2.3 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
 - 1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.
 - a. Manufacturers:
 - 1) Clamp-All Corp.
 - 2. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.
 - a. Manufacturers:
 - 1) MG Piping Products Co.

2.4 PVC PIPE AND FITTINGS

- A. Solid-Wall Schedule 40 PVC Pipe: ASTM D 2665, drain, waste, and vent.

1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

2.5 SPECIAL PIPE FITTINGS

- A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
 1. Manufacturers:
 - a. Fernco, Inc.
 - b. Mission Rubber Co.
 2. Sleeve Materials:
 - a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - b. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - c. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
- B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 1. Manufacturers:
 - a. Mission Rubber Co.
- C. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
 1. Manufacturers:
 - a. Dresser, Inc.; DMD Div.
 - b. Romac Industries, Inc.
 2. Center-Sleeve Material: Stainless steel.
 3. Gasket Material: Natural or synthetic rubber.
 4. Metal Component Finish: Corrosion-resistant coating or material.
- D. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
 1. Manufacturers:
 - a. EBAA Iron Sales, Inc.
 - b. Romac Industries, Inc.
 - c. Star Pipe Products; Star Fittings Div.
- E. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with

AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

1. Manufacturers:
 - a. SIGMA Corp.

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Refer to Division 2 Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.
- B. Aboveground, soil, waste and vent piping NPS 6 and smaller shall be any of the following:
 1. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and coupled joints.
 2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints (non-return air plenum locations only, verify all locations prior to purchase of pipe).
 3. Dissimilar Pipe-Material Couplings: Flexible, Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
- C. Underground, soil, waste, and vent piping NPS 6 and smaller shall be any of the following:
 1. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
 2. Sewer and Drain Series, PVC pipe; PVC socket fittings; and solvent-cemented joints.
 3. Dissimilar Pipe-Material Couplings: Flexible, Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

3.3 PIPING INSTALLATION

- A. Sanitary sewer piping outside the building is specified in Division 2 Section "Sanitary Sewerage."
- B. Basic piping installation requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."
- C. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.
- D. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 15 Section "Basic Mechanical Materials and Methods."
- E. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

- F. Make changes in direction for soil and waste drainage and vent 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 drainage 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 soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
 - 1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
 - 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- I. Install engineered soil and waste drainage and vent piping systems as follows:
 - 1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
 - 2. Solvent Drainage System: Comply with ASSE 1043 and solvent fitting manufacturer's written installation instructions.
- J. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
- K. Install underground PVC soil and waste drainage piping according to ASTM D 2321.
- L. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."
- B. 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.
- C. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 15 Section "Hangers and Supports." Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.

2. Install individual, straight, horizontal piping runs according to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet : MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet , if Indicated: MSS Type 49, spring cushion rolls.
 3. Multiple, Straight, Horizontal Piping Runs 100 Feet 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 "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, with 3/8-inch minimum rods.
- E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4 : 72 inches with 3/8-inch rod.
 2. NPS 1-1/2 and NPS 2 : 96 inches with 3/8-inch rod.
 3. NPS 2-1/2: 108 inches with 1/2-inch rod.
 4. NPS 3 to NPS 5 : 10 feet with 1/2-inch rod.
 5. NPS 6 : 10 feet with 5/8-inch rod.
 6. NPS 8 : 10 feet with 3/4-inch) rod.
- F. Install supports for vertical copper tubing every 10 feet .
- G. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2 : 48 inches with 3/8-inch rod.
 2. NPS 3 : 48 inches with 1/2-inch rod.
 3. NPS 4 and 5 : 48 inches with 5/8-inch rod.
 4. NPS 6 : 48 inches with 3/4-inch rod.
 5. NPS 8 to NPS 12 : 48 inches with 7/8-inch rod.
- H. Install supports for vertical PVC piping every 48 inches.
- I. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.
- 3.6 CONNECTIONS
- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. 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.
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.

3.7 FIELD QUALITY CONTROL

- A. 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.
 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent 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.

3.8 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.

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

3.9 PROTECTION

- A. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

END OF SECTION 221316

SECTION 221319 - DRAINAGE PIPING 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.

1.2 SUMMARY

- A. This Section includes the following drainage piping specialties:
 - 1. Backwater valves.
 - 2. Cleanouts.
 - 3. Floor drains.
 - 4. Roof Drains.
 - 5. Through-penetration firestop assemblies.
 - 6. Miscellaneous drainage piping specialties.
 - 7. Flashing materials.
 - 8. Grease interceptors.
- B. Related Sections include the following:
 - 1. Division 15 Section "Plumbing Fixtures" for hair interceptors.
 - 2. Division 15 Section "Medical Plumbing Fixtures" for plaster sink interceptors.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for the following:
 - 1. Grease interceptors.
 - 2. Backwater valves.
 - 3. Cleanouts.
 - 4. Floor drains.
 - 5. Roof Drains.
 - 6. Through-penetration firestop assemblies.
 - 7. Miscellaneous drainage piping specialties.
 - 8. Flashing materials.
- B. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

- B. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary and storm piping specialty components.

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.
- B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 BACKWATER VALVES

- A. Horizontal, PVC Backwater Valves
 - 1. 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:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 3. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
 - a. Canplas Industries
 - b. Plastic Trends
 - c. Flo Control, Inc.
 - 4. Approvals: BOCA, CSA, IAPMO, SBCC1
 - 5. Size: Same as connected piping.
 - 6. Body: PVC
 - 7. End Connections: hubless.
 - 8. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
 - 9. Extension: ASTM A 74, Service class; full-size, PVC, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

2.2 CLEANOUTS

- A. Exposed Metal Cleanouts:
 - 1. 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:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 3. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

- a. Josam Company; Josam Div.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Zurn Plumbing Products Group; Specification Drainage Operation.
4. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
 5. Size: Same as connected drainage piping
 6. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
 7. Closure: Countersunk or raised-head, brass plug.
 8. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
 9. Closure: Stainless-steel plug with seal.

B. Cast-Iron Wall Cleanouts:

1. 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:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 3. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
 - a. Josam Company; Josam Div.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Zurn Plumbing Products Group; Specification Drainage Operation.
4. Standard: ASME A112.36.2M. Include wall access.
 5. Size: Same as connected drainage piping.
 6. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
 7. Closure: Countersunk or raised-head brass plug.
 8. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
 9. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
 10. Wall Access: Square, stainless-steel wall-installation frame and cover.

2.3 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. 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:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 3. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
 - a. Josam Company; Josam Div.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Zurn Plumbing Products Group; Light Commercial Operation.
4. Standard: ASME A112.6.3.
 5. Pattern: Floor drain.
 6. Body Material: Cast iron.

7. Seepage Flange: Required.
8. Anchor Flange: Required.
9. Clamping Device: Required.
10. Outlet: Bottom
11. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant enamel.
12. Top or Strainer Material: Nickel bronze
13. Top of Body and Strainer Finish: Nickel bronze
14. Top Shape: Square.
15. Top Loading Classification: Heavy Duty.
16. Trap Material: Cast iron.
17. Trap Pattern: Deep-seal P-trap.
18. Trap Features: Trap-seal primer valve drain connection.

2.4 ROOF DRAINS

A. Metal Roof Drains:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide or a comparable product by one of the following:
 - a. Josam Company; Josam Div.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Zurn Plumbing Products Group; Light Commercial Operation.
4. Standard: ASME A112.21.2M.
5. Pattern: Roof drain.
6. Body Material: Cast iron.
7. Combination Flashing Ring and Gravel Stop: Required.
8. Flow-Control Weirs: Required for overflow roof drain only.
9. Outlet: Bottom.
10. Dome Material: Cast iron.
11. Extension Collars: Required.
12. Underdeck Clamp: Required.
13. Sump Receiver: Required.

2.5 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ProSet Systems Inc.

- b. 3M Corporation.
- 3. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
- 4. Size: Same as connected soil, waste, or vent stack.
- 5. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
- 6. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
- 7. Special Coating: Corrosion resistant on interior of fittings.

2.6 MISCELLANEOUS DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:

- 1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
- 2. Size: Same as connected waste piping.
 - a. NPS 2: 4-inch- minimum water seal.
 - b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

B. Floor-Drain, Trap-Seal Primer Fittings:

- 1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
- 2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

C. Air-Gap Fittings:

- 1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
- 2. Body: Bronze or cast iron.
- 3. Inlet: Opening in top of body.
- 4. Outlet: Larger than inlet.
- 5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

D. Sleeve Flashing Device:

- 1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 1 inch above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
- 2. Size: As required for close fit to riser or stack piping.

E. Stack Flashing Fittings

- 1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
- 2. Size: Same as connected stack vent or vent stack.

F. Expansion Joints:

1. Standard: ASME A112.21.2M.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

2.7 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:

1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.

B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:

1. General Applications: 12 oz./sq. ft. .
2. Vent Pipe Flashing: 8 oz./sq. ft. .

C. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

E. Fasteners: Metal compatible with material and substrate being fastened.

F. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

G. Solder: ASTM B 32, lead-free alloy.

H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.8 GREASE INTERCEPTORS

A. Grease Interceptors:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide or a comparable product by one of the following:
 - a. Applied Chemical Technology, Incorporated.

- b. Josam Company; Josam Div.
 - c. Oldprecastle Precast Co.
 - d. Rockford Sanitary Systems, Inc.
 - e. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
-
- 4. Standard: ASME A112.14.3[and PDI-G101], for intercepting and retaining fats, oils, and greases from food[-preparation] wastewater.
 - 5. Plumbing and Drainage Institute Seal: Required.
 - 6. Body Material: Reinforced concrete.
 - 7. Body Dimensions: See drawing detail.
 - 8. Body Extension: Required.
 - 9. Grease Retention Capacity: See drawing detail.
 - 10. Inlet and Outlet Size: See drawing detail.
 - 11. Cleanout: field installed on inlets and outlets.
 - 12. Mounting: Below grade.
 - 13. Operation: Manual cleaning.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for piping joining materials, joint construction, and basic installation requirements.
- B. Install backwater valves in building drain piping. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.
- C. 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 3 and smaller and 100 feet for larger piping.
 - 4. Locate at base of each vertical soil and waste stack.
- D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- F. 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.
- G. Install through-penetration firestop assemblies in plastic stacks at floor penetrations.
- H. Assemble open drain fittings and install with top of hub 1 inch, 2 inches above floor.
- I. Install deep-seal traps on floor drains and other waste outlets, if indicated.
- J. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 2. Size: Same as floor drain inlet.
- K. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- L. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- M. 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.
- N. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 7.
 1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 2. Position roof drains for easy access 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 equipment to allow service and maintenance.

3.3 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft. , 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
 2. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches and skirt or flange extending at least 8 inches around pipe.
 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 7 Section "Sheet Metal Flashing and Trim."
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.
- 3.4 LABELING AND IDENTIFYING
- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
1. Grease interceptors.
- 3.5 FIELD QUALITY CONTROL
- A. Perform tests and inspections and prepare test reports.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled grease removal devices and their installation, including piping and electrical connections, and to assist in testing.
- B. Tests and Inspections:
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- 3.6 PROTECTION
- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain grease removal devices. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION 221319

SECTION 221413 - STORM DRAINAGE 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.

1.2 SUMMARY

- A. This Section includes the following storm drainage piping inside the building:
 - 1. Pipe, tube, and fittings.
 - 2. Special pipe fittings.

1.3 DEFINITIONS

- A. PVC: Polyvinyl chloride plastic.
- B. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
 - 1. Storm Drainage Piping: 10-foot head of water.

1.5 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Shop Drawings:
 - 1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.
- C. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

- B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPING MATERIALS

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

2.3 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
 - 1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.
 - a. Manufacturers:
 - 1) Clamp-All Corp.
 - 2. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.
 - a. Manufacturers:
 - 1) MG Piping Products Co.

2.4 PVC PIPE AND FITTINGS

- A. Solid-Wall Schedule 40 PVC Pipe: ASTM D 2665, drain, waste, and vent.
 - 1. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

2.5 SPECIAL PIPE FITTINGS

- A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 1. Manufacturers:
 - a. Fernco, Inc.
 - b. Mission Rubber Co.
 - 2. Sleeve Materials:
 - a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - b. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - c. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
- B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 1. Manufacturers:
 - a. Mission Rubber Co.
- C. Rigid, Unshielded, Nonpressure Pipe Couplings: ASTM C 1461, sleeve-type reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 1. Manufacturers:
 - a. ANACO.
- D. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
 - 1. Manufacturers:
 - a. Cascade Waterworks Mfg. Co.
 - b. Romac Industries, Inc.
 - 2. Center-Sleeve Material: Stainless steel.
 - 3. Gasket Material: Natural or synthetic rubber.
 - 4. Metal Component Finish: Corrosion-resistant coating or material.
- E. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
 - 1. Manufacturers:
 - a. Romac Industries, Inc.
 - b. Star Pipe Products; Star Fittings Div.

- F. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
 - 1. Manufacturers:
 - a. SIGMA Corp.

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Refer to Division 2 Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.
- B. Aboveground storm drainage piping NPS 6 and smaller shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and coupled joints.
 - 3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints (non-return air plenum locations only, verify all locations prior to purchase of pipe).
 - 4. Dissimilar Pipe-Material Couplings: Flexible & Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
- C. Aboveground, storm drainage piping NPS 8 and larger shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and coupled joints.
 - 3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints (non-return air plenum locations only, verify all locations prior to purchase of pipe).
 - 4. Dissimilar Pipe-Material Couplings: Flexible & Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
- D. Underground storm drainage piping NPS 6 and smaller shall be any of the following:
 - 1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
 - 2. Dissimilar Pipe-Material Couplings: Flexible & Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
- E. Underground, storm drainage piping NPS 8 and larger shall be any of the following:
 - 1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
 - 2. Dissimilar Pipe-Material Couplings: Flexible, Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

3.3 PIPING INSTALLATION

- A. Storm sewer and drainage piping outside the building are specified in Division 2 Section "Storm Drainage."
- B. Basic piping installation requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."
- C. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 15 Section "Plumbing Specialties."
- D. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 15 Section "Basic Mechanical Materials and Methods."
- E. Install wall-penetration fitting system at each service pipe penetration through foundation wall. Make installation watertight.
- F. 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."
 - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.
- G. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. 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.
- H. Lay buried building storm drainage 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.
- I. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:
 - 1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.
- J. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- K. Install PVC storm drainage piping according to ASTM D 2665.
- L. Install underground PVC storm drainage piping according to ASTM D 2321.
- M. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."
- B. Hubless Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
- C. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

3.5 VALVE INSTALLATION

- A. General valve installation requirements are specified in Division 15 Section "Valves."
- B. Shutoff Valves: Install shutoff valve on each sump pump discharge.
 - 1. Install gate or full-port ball valve for piping NPS 2 and smaller.
 - 2. Install butterfly valve for piping NPS 2-1/2 and larger.
- C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sump pump discharge.
- D. Backwater Valves: Install backwater valves in piping subject to backflow.
 - 1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
 - 2. Install backwater valves in accessible locations.
 - 3. Backwater valve are specified in Division 15 Section "Plumbing Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 15 Section "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 and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet 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 "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, with 3/8-inch minimum rods.

- E. 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.
 - 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 - 4. NPS 6: 60 inches with 3/4-inch rod.
 - 5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.
 - 6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every 15 feet.
- G. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
 - 2. NPS 3: 48 inches with 1/2-inch rod.
 - 3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
 - 4. NPS 6: 48 inches with 3/4-inch rod.
 - 5. NPS 8 to NPS 12: 48 inches with 7/8-inch rod.
- H. Install supports for vertical PVC piping every 48 inches.
- I. 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. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect storm drainage piping to roof drains and storm drainage specialties.

3.8 FIELD QUALITY CONTROL

- A. 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.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

- D. Test storm drainage 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 storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Test Procedure: Test storm drainage piping, 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. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 5. Prepare reports for tests and required corrective action.
- E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 2. 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.
 - 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 4. Prepare reports for tests and required corrective action.

3.9 CLEANING

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

END OF SECTION 221413

SECTION 223300 - 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following electric water heaters:

- 1. Household, storage electric water heaters.

1.3 SUBMITTALS

- A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Source quality-control test reports.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For electric water heaters to include in emergency, operation, and maintenance manuals.

- G. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain same type of electric water heaters through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of electric water heaters and are based on the specific system indicated. Refer to Division 01 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. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.
- E. ASME Compliance: Where indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- F. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for all components that will be in contact with potable water.

1.5 COORDINATION

- A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric water heaters that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - 2. Warranty Period(s): From date of Substantial Completion:
 - a. Household Electric Water Heaters:
 - 1) Storage Tank: Five years.
 - 2) Controls and Other Components: Two years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 HOUSEHOLD ELECTRIC WATER HEATERS

- A. Household, Standard, Storage Electric Water Heaters: Comply with UL 174.
1. Manufacturers:
 - a. American Water Heater Company.
 - b. Bradford White Corporation.
 - c. Heat Transfer Products, Inc.
 - d. Lochinvar Corporation.
 - e. Rheem Water Heater Div.; Rheem Manufacturing Company.
 - f. Ruud Water Heater Div.; Rheem Manufacturing Company.
 - g. Smith, A. O. Water Products Company.
 - h. State Industries, Inc.
 2. Storage-Tank Construction: Steel.
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: 150 psig.
 - c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 3. Factory-Installed Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: ASSE 1005.
 - d. Insulation: Comply with ASHRAE/IESNA 90.1-2004.
 - e. Jacket: Steel with enameled finish.
 - 1) Standard: Cylindrical shape.
 - 2) Tabletop: Rectangular shape, with flat-top work surface and raised back.
 - f. Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - g. Heating Elements: Two; electric, screw-in immersion type with 12 kW or less total, and wired for nonsimultaneous operation, unless otherwise indicated.
 - h. Temperature Control: Adjustable thermostat for each element.
 - i. Safety Control: High-temperature-limit cutoff device or system.

- j. Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. 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 storage tank.
 - 4. Capacity and Characteristics: See hot water heater schedule on drawings.
- B. Commercial, Storage Electric Water Heaters: Comply with UL 1453 requirements for storage-tank-type water heaters.
- 1. Manufacturers:
 - a. Bock Water Heaters, Inc.
 - b. Lochinvar Corporation.
 - c. PVI Industries, LLC.
 - d. RECO USA.
 - e. Rheem Water Heater Div.; Rheem Manufacturing Company.
 - f. Ruud Water Heater Div.; Rheem Manufacturing Company.
 - g. Smith, A. O. Water Products Company.
 - h. State Industries, Inc.
 - 2. Storage-Tank Construction: ASME -code, steel vertical arrangement.
 - a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
 - 1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
 - 2) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - b. Pressure Rating: 150 psig.
 - c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - 3. Factory-Installed Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - c. Insulation: Comply with ASHRAE/IESNA 90.1.
 - d. Jacket: Steel with enameled finish.
 - e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
 - 1) Staging: Input not exceeding: See hot water heater schedule on drawings.
 - f. Temperature Control: Adjustable thermostat.
 - g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
 - h. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include

pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

4. Special Requirements: NSF 5 construction.
5. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.
 - 1) Capacity and Characteristics: See hot water heater schedule on drawings

2.3 COMPRESSION 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.

1. Manufacturers:

- a. AMTROL Inc.
- b. Armstrong Pumps, Inc.
- c. Flexcon Industries.
- d. Honeywell Sparco.
- e. Smith, A. O.; Aqua-Air Div.
- f. State Industries, Inc.
- g. Taco, Inc.
- h. Watts Regulator Co.

2. Construction:

- a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1, pipe thread.
- b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
- c. Air-Charging Valve: Factory installed.

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 valves with sensing element that extends into storage tank.
- B. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than water heater working-pressure rating.
- C. Water Heater Stand and Drain-Pan Units: High-density-polyethylene-plastic, 18-inch- 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 drain outlet with ASME B1.20.1 pipe thread.
- D. 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 above the floor.

- E. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.
- F. 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 3/4.
- G. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that are capable of isolating each water heater and of providing balanced flow through each water heater.
- H. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1-2004.
- I. Water Regulators: ASSE 1003, water-pressure reducing valve. Set at 25-psig- maximum outlet pressures, unless otherwise indicated.
- J. Shock Absorbers: ASSE 1010 or PDI WH 201, Size A water hammer arrester.

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- B. Prepare test reports.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

- A. Install commercial water heaters on concrete bases.
 - 1. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
 - 2. Concrete base construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. 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.
- C. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- D. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

- E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains 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 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.
- F. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.
- G. Install thermometers on inlet and outlet piping of household, collector-to-tank, solar-electric water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.
- H. Install pressure gage on outlet of commercial electric water- heater piping. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.
- I. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve, thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves and to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.
- J. Install water regulator, with integral bypass relief valve, in booster-heater inlet piping and water hammer arrester in booster-heater outlet piping.
- K. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.
- L. Fill water heaters with water.
- M. Charge compression tanks with air.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial electric water heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 223300

SECTION 224000 - 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.

1.2 SUMMARY

- A. This Section includes the following conventional plumbing fixtures and related components:
 - 1. Faucets for lavatories and sinks.
 - 2. Faucet-spout outlets.
 - 3. Toilet seats.
 - 4. Fixture supports.
 - 5. Water closets.
 - 6. Lavatories.
 - 7. Sinks.
 - 8. Service sinks.
- B. Related Sections include the following:
 - 1. Division 2 Section "Water Distribution" for exterior plumbing fixtures and hydrants.
 - 2. Division 15 Section "Plumbing Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
- C. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.
- D. FRP: Fiberglass-reinforced plastic.
- E. PVC: Polyvinyl chloride plastic.

- F. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.4 SUBMITTALS

- A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Warranty: Special warranty specified in this Section.

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. 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"; for plumbing fixtures for people with disabilities.
- C. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- D. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
- E. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
- F. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
 - 1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
 - 2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
 - 3. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
 - 4. Stainless-Steel Residential Sinks: ASME A112.19.3.
 - 5. Vitreous-China Fixtures: ASME A112.19.2M.
 - 6. Water-Closet, Flushometer Tank Trim: ASSE 1037.
- G. 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. Faucets: ASME A112.18.1.
 5. Hose-Connection Vacuum Breakers: ASSE 1011.
 6. Hose-Coupling Threads: ASME B1.20.7.
 7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
 8. NSF Potable-Water Materials: NSF 61.
 9. Pipe Threads: ASME B1.20.1.
 10. Supply Fittings: ASME A112.18.1.
 11. Brass Waste Fittings: ASME A112.18.2.
- H. 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 A112.18.1.
 3. Manual-Operation Flushometers: ASSE 1037.
 4. Plastic Tubular Fittings: ASTM F 409.
 5. Brass Waste Fittings: ASME A112.18.2.
- I. Comply with the following applicable standards and other requirements specified for miscellaneous components:
1. Flexible Water Connectors: ASME A112.18.6.
 2. Floor Drains: ASME A112.6.3.
 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 Toilet Seats: ANSI Z124.5.
 7. Supply and Drain Protective Shielding Guards: ICC A117.1.

PART 2 - PRODUCTS

- 2.1 Refer to contract documents for basics of design of plumbing fixtures.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.
- B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
 - 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-mounting fixtures onto waste fitting seals and attach to supports.
- D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.
- E. Install wall-mounting fixtures with tubular waste piping attached to supports.
- F. Install floor-mounting attached to building floor substrate bracket and onto waste fitting seals.
- G. Install counter-mounting fixtures in and attached to casework.
- H. Install fixtures level and plumb according to roughing-in drawings.
- I. 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 valves if supply stops are not specified with fixture. Valves are specified in Division 15 Section "Valves."
- J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
- L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
- M. Install toilet seats on water closets.
- N. Install traps on fixture outlets.
 - 1. Exception: Omit trap on fixtures with integral traps.
- O. 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. Escutcheons are specified in Division 15 Section "Basic Mechanical Materials and Methods."

- P. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 7 Section "Joint Sealants."

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 fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- C. Ground equipment according to Division 16 Section "Grounding and Bonding."
- D. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
- B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
- C. Inspect installed plumbing 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. Operate and adjust disposers and controls. Replace damaged and malfunctioning units and controls.
- C. Adjust water pressure at faucets and flushometer to produce proper flow and stream.
- D. 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.
- B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

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

END OF SECTION 224000

SECTION 230000 - MECHANICAL & PLUMBING SUPPLEMENTAL REQUIREMENTS**PART 1 - GENERAL****1.1 REFERENCES**

- A. This entire section forms an integral part of each HVAC, Electrical, Plumbing, Fire Protection, Controls and all other related Mechanical and Electrical sections included in the 230000 and 260000 series of the specifications.
- B. Conditions of the Contract 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.
- C. Examine Drawings and other Sections of Specifications for requirements that affect work of this Section.
- D. Attention is directed to the following specialized requirements of this Part I:
 - 1. Article 1.7 REQUEST FOR INFORMATION (RFI) PROCEDURE. This Article describes the requirements of the Contractor when submitting RFIs.
 - 2. Article 1.13 GUARANTEE AND 24 HOUR SERVICE. The requirement to provide a 24 hour phone number for service during the guarantee period is incorporated; also, an extended warranty to cover the full one year contractor's guarantee period starting on the date of substantial completion, even if equipment has been previously used for temporary heat or other purpose.
 - 3. Article 1.14 RECORD DOCUMENTS. A requirement to incorporate photographs, taken during construction, of buried and concealed components is incorporated.
 - 4. Article 1.18 SUBMITTALS. A special cover sheet for each submittal, to be filled out by the contractor, is required. A description of "Acceptable Manufacturers" is included. No other manufacturers will be considered for this project. The turn-around time Engineer requires to process submittals is defined.

1.2 DEFINITIONS

- A. As used in these Sections, "provide," means "furnish and install." "Furnish" means "to purchase and deliver to the project site complete with every necessary appurtenance and support," and "Install" means "to unload at the delivery point at the site and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project. "Architect" means the "Prime Design Consultant," and if Ingenuity, Inc. is not the prime design consultant, the Architect may authorize Ingenuity, Inc. to act on the Architect's behalf in matters concerning the 210000, 220000, 230000 and 260000, 270000 series of specifications. "RFI" means Contractor's "Request for Information."

1.3 SCOPE

- A. Perform work and provide material and equipment as shown on Drawings and/or as specified and/or indicated in this Section of the Specifications. Completely coordinate work of Sections (Divisions 21, 22, 23 and 26, 27) with work of other trades and provide a complete and fully functional installation.
- B. Drawings and Specifications form complementary requirements; provide work specified and not shown, and work shown and not specified as though explicitly required by both. Although work is not specifically shown or specified, provide supplementary or miscellaneous items, appurtenances, devices and materials obviously necessary for a sound, secure and complete installation.
- C. It is the intent that these Specifications and Drawings are to establish minimum requirements for methods, products and equipment and to provide electrical service, distribution and systems finished, tested and ready for operation. Incidental detail not usually shown or specified, but necessary for proper installation and operation shall be included in the work and this Contractor's estimate, the same as if specified. Locations of all equipment and material shall be adjusted at no extra cost to the Owner, to accommodate the work interferences anticipated and/or encountered. Prior to installation, determine the exact route and location of each raceway and piece of equipment to minimize conflicts with other trades.
- D. Give notices, file plans, obtain permits and licenses, pay fees and backcharges, and obtain necessary approvals from authorities that have jurisdiction as required to perform work in accordance with all legal requirements and with Specifications, Drawings, Addenda and Change Orders, all of which are part of Contract Documents.
- E. This project will be phased, as defined by the Owner. This will necessitate the provision of temporary valving and capping of Mechanical, Electrical, Plumbing and Fire Protection utilities. All associated appurtenances with the utilities shall be provided as part of this project.
- F. The scope of electrical work shall include all labor, materials, tools, equipment and services necessary for, or incidental to proper installation and completion of the work indicated on the Drawings and stated within these Specifications.
 - 1. Unless otherwise noted, provide labor and materials to install electrical disconnects, pushbutton stations, controllers and motor starters supplied by other trades.
 - 2. Unless otherwise noted, provide labor and materials to make final electrical connections to motors, controllers and starters and electrical interconnections between equipment supplied by other trades.
 - 3. Division 23 Contractor shall furnish all motor starters and disconnect switches as required by NEC for HVAC motors, unless specifically noted otherwise in the specifications or on the drawings. Motor starters and disconnect switches shall be in accordance with Division 26 Specifications.
- G. These documents describe the systems required and approximately where the larger equipment is to be located. This contractor shall include allowances in his estimates to fully

complete the system including all interconnecting and coordination and installation details and components and extending the system into and throughout all spaces. He shall also include allowances for startup and for making the systems fully operational, and for scope and design contingencies. Future changes in price above the GMP or selected Bid, for items not shown on these drawings will not be allowed if the system itself is shown or described in these documents. The only future changes in price that will be allowed are if new systems are added.

- H. If a Guaranteed Maximum Price (GMP) has been prepared using documents prior to the issuance of the 100% Bid Documents, the Contractor shall identify any and all changes to the documents (both drawings and specifications) that are affecting the GMP, either increasing or decreasing the GMP amount. All changes shall be numbered and circled, in both drawings and specifications. The Contractor shall also provide detailed cost back-up for all items noted above.

1.4 CONTRACT DOCUMENTS

- A. Listing of Drawings does not limit responsibility of determining full extent of work required by these Contract Documents. Refer to Architectural, HVAC, Plumbing, Fire Protection, Electrical, Structural, Site Utility and all other Drawings and other Sections that indicate types of construction in which work shall be installed and work of other trades with which work of Sections (Divisions 21, 22, 23 and 26, 27) must be coordinated.
- B. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any item, in the drawings or specifications or both, carries with it the instruction to furnish and install the item, regardless of whether or not this instruction is explicitly stated as part of the indication or description.
- C. Items referred to in singular number in Contract Documents shall be provided in quantities necessary to complete work.
- D. Drawings are diagrammatic. They are not intended to be absolutely precise; they are not intended to specify or to show every offset, fitting, and component. The purpose of the drawings is to indicate a systems concept, the main components of the systems, and the approximate geometrical relationships. Based on the systems concept, the main components, and the approximate geometrical relationships, the contractor shall provide all other components and materials necessary to make the systems fully complete and operational.
- E. Information and components shown on riser diagrams but not shown on plans, and vice versa, shall apply or be provided as if expressly required on both.
- F. Data that may be furnished electronically by the Architect (on computer tape, diskette, or otherwise) is diagrammatic. Such electronically furnished information is subject to the same limitation of precision as heretofore described. If furnished, such data is for convenience and generalized reference, and shall not substitute for Architect's sealed or stamped construction documents.

1.5 DISCREPANCIES IN DOCUMENTS

- A. Where Drawings or Specifications conflict or are ambiguous, advise Architect in writing before Award of Contract. Otherwise, Architect's interpretation of Contract Documents shall be final, and no additional compensation shall be permitted due to discrepancies or ambiguities thus resolved.
- B. Where Drawings or Specifications do not coincide with manufacturers' recommendations, or with applicable codes and standards, alert Architect in writing before installation. Otherwise, make changes in installed work as Architect requires within Contract Price.
- C. If the required material, installation, or work can be interpreted differently from drawing to drawing, or between drawings and specifications, this contractor shall provide that material, installation, or work which is of the higher, more stringent standard.
- D. It is the requirement of the Contract Documents to have the contractor provide systems and components that are fully complete, operational and suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem, or the routing of a component or its coordination with other building elements. In cases such as this, where the Contractor has failed to notify the Architect of the situation in accordance with Paragraph (A) above, the Contractor shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in workmanlike manner either concealed or exposed per the design intent.
- E. In cases covered by Paragraph (D) above, where the Contractor believes he needs engineering guidance, he shall submit a sketch identifying his proposed solution and the Architect shall review and advise of disposition (refer to Article 1.7).

1.6 MODIFICATIONS IN LAYOUT

- A. HVAC, Plumbing, Fire Protection, and Electrical Drawings are diagrammatic. They indicate general arrangements of mechanical and electrical systems and other work. They do not show all offsets required for coordination nor do they show the exact routings and locations needed to coordinate with structure and other trades and to meet Architectural requirements.
- B. In order to obtain the Architect's desired aesthetics in spaces used by building occupants, in all such spaces, prior to installation of visible material and equipment (including access panels) review Architectural Drawings for desired locations and where not definitely indicated, request information from Architect.
- C. Check Contract Documents, as well as, Submittals and Shop Drawings of all subcontractors to verify and coordinate spaces in which work of Divisions 21, 22, 23 and 26, 27 will be installed.
- D. Maintain maximum headroom at all locations. All piping, duct, conduit and associated components to be as tight to underside of structure as possible.
- E. Make reasonable modifications in layout and components needed to prevent conflict with work of other trades and to coordinate according to Paragraphs A, B, C and D above. Systems shall be run in a rectilinear fashion.

- F. Where conflicts or potential conflicts exist and engineering guidance is desired, submit sketch of proposed resolution to Architect for review and approval (refer to Article 1.7).

1.7 REQUESTS FOR INFORMATION (RFI'S)

- A. If the RFI is a request to resolve a conflict or an ambiguity, or a request for additional detail, Contractor's RFI shall include a sketch or equivalent description of Contractor's proposed solution, in accordance with paragraphs 1.5 (E) and 1.6 (F) above.
- B. To expedite the flow of RFI's, for all RFI's under Divisions 23 and 26, Contractor shall submit the attached form, or similar form including the same information, to the Architect, with copy to Engineer. Contractor shall include proposed solution in the indicated space on the form.

1.8 COORDINATION DRAWINGS

- A. When included as part of the Contract Documents, there shall be full cooperation and coordination of all specialty trades.
- B. The Division 21, 22, 23 and 26, 27 Contractors shall both comply fully with the requirements set forth in the "Coordination Drawings" specification section. At a minimum, this shall include the following trades:
 - 1. Mechanical Ductwork
 - 2. Mechanical Piping
 - 3. Plumbing
 - 4. Electrical
 - 5. Fire Protection (sprinkler system)
 - 6. Controls
 - 7. Special Building Systems
- C. Refer to the Coordination Drawings specification section for specific requirements.
- D. The following work is required by, but not specified in, Division 15 and 16 and shall be performed in compliance with the appropriate Sections.
 - 1. Excavation and backfill.
 - 2. Concrete work, including concrete housekeeping pads and other pads and blocks for vibrating and rotating equipment, ductbank envelopes and cast-in-place manholes and handholes.

3. 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.
4. Flashing of wall and roof penetrations.
5. Installation of access panels in floors, walls, and furred spaces or above ceilings.
6. Painting, except as specified herein.
7. Structural supports necessary to distribute loading from equipment to roof or floor, except as specified herein.
8. Temporary light, power, water, heat, gas and sanitary facilities for use during construction and testing.
9. Outdoor air intake and exhaust louvers.

1.9 SITE VISIT

- A. Before submitting bid, visit and carefully examine site to identify existing conditions and difficulties that will affect work of Divisions 21, 22, 23 and 26, 27. No extra payment will be allowed for additional work caused by unfamiliarity with site conditions that are visible or readily construed by an experienced observer.

1.10 EXISTING CONDITIONS AND PREPARATORY WORK

- A. Before starting work in a particular area of the project, visit site and examine conditions under which work must be performed including preparatory work done under other Sections or other Contracts or by the Owner. Report conditions that might affect work adversely, in writing, through Contractor to Architect via RFI. 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.

1.11 CODES, STANDARDS, AUTHORITIES AND PERMITS

- A. Perform work strictly as required by rules, regulations, standards, codes, ordinances, and laws of local, state, and Federal governments, and other authorities that have legal jurisdiction over the site.
- B. Prior to commencement of work, notify State and applicable authorities as required and submit all of the applicable notifications for construction, operation and/or demolition.
- C. Materials and equipment shall be manufactured, installed and tested as specified in latest editions of applicable publications, standards, rulings and determinations of:
 1. Local and state building, plumbing, mechanical, electrical, fire and health department codes.
 2. Air Movement and Controls Association, Inc. (AMCA)

3. American Gas Association (AGA).
 4. American Society of Plumbing Engineers (ASPE).
 5. Cast Iron Soil Pipe Institute (CISPI).
 6. Factory Mutual Association (FM).
 7. Mechanical Contractors Association (MCA).
 8. Manufacturers Standardization Society (MSS).
 9. National Bureau of Standards (NBS).
 10. National Electrical Code (NEC).
 11. National Fire Protection Association (NFPA).
 12. National Sanitation Foundation (NSF).
 13. Plumbing and Drainage Institute (PDI).
 14. American Insurance Association (A.I.A.) (formerly National Board of Fire Underwriters).
 15. Occupational Safety and Health Act (OSHA).
 16. Underwriters Laboratories (UL)
 17. Water Conditioning Foundation (WCF).
 18. Owner's Insurance Underwriter.
- D. Material and equipment shall be listed by Underwriters' Laboratories (UL), and approved by ASME, ANSI, ASTM, and AGA for intended service.
- E. Fire protection equipment shall be listed by Underwriters' Laboratories (UL) and/or Factory Mutual (FM) approved for fire service.
- F. When requirements cited in this Specification conflict with each other or with Contract Documents, the most stringent shall govern work. Architect may relax this requirement when such relaxation does not violate ruling of authorities that have jurisdiction. Approval for such relaxation shall be obtained in writing.
- G. Most recent editions of applicable specifications and publications of the following organizations form part of these Contract Documents.
1. American Gas Association (AGA).
 2. Air Movement and Control Association (AMCA).

3. American National Standards Institute (ANSI).
4. Air-Conditioning and Refrigeration Institute (ARI).
5. American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE).
6. American Society of Mechanical Engineers (ASME).
7. American Society of Plumbing Engineers (ASPE).
8. American Society of Sanitary Engineering (ASSE).
9. American Society for Testing and Materials (ASTM).
10. American Water Works Association (AWWA).
11. Cast Iron Soil Pipe Institute (CISPI).
12. Certified Ballast Manufacturers (CMB).
13. Factory Mutual Engineering (FM).
14. Manufacturer's Standardization Society of the Valve & Fittings Industry (HSS)
15. Insulated Cable Engineers Association (ICEA).
16. Institute of Electrical and Electronics Engineers (IEEE).
17. Illuminating Engineering Society (IES).
18. Mechanical Contractors Association (MCA).
19. National Bureau of Standards (NBS).
20. National Electrical Code (NEC).
21. National Electric Manufacturers Association (NEMA).
22. National Fire Protection Association (NFPA).
23. National Sanitation Foundation (NSF).
24. Plumbing and Drainage Institute (PDI).
25. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
26. Thermal Insulation Manufacturers Association (TIMA).
27. Underwriters Laboratories (UL).

28. Water Conditioning Foundation (WCF).

H. The complete installation shall comply with the following codes:

- | | | | |
|-----|---|------|--|
| 1. | NFPA 1 | 2006 | Uniform Fire Code |
| 2. | NFPA 13 | 2013 | Standard for the Installation of Sprinkler Systems |
| 3. | NFPA 13R | 2013 | Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height |
| 4. | NFPA 24 | 2013 | Standard for the Installation of Private Fire Service Mains and Their Appurtenances |
| 5. | NFPA 25 | 2013 | Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems |
| 6. | NFPA 51B | 2003 | Standard for Fire Protection During Welding, Cutting and Other Hot Work |
| 7. | NFPA 70 | 2014 | National Electrical Code |
| 8. | NFPA 72 | 2013 | National Fire Alarm Code |
| 9. | NFPA 75 | 2003 | Standard for the Protection of Information Technology Equipment |
| 10. | NFPA 90A | 2013 | Standard for the Installation of Air Conditioning and Ventilating Systems |
| 11. | NFPA 92A | 2006 | Standard for Smoke – Control Systems Utilizing Barriers and Pressure Differences |
| 12. | NFPA 96 | 2004 | Standard for Ventilation Control and Fire Prevention of Commercial Cooking Operations |
| 13. | NFPA 99 | 2005 | Standard for Health Care Facilities |
| 14. | NFPA 101 | 2012 | Life Safety Code |
| 15. | NFPA 110 | 2005 | Standard for Emergency and Standby Power Systems |
| 16. | NFPA 780 | 2004 | Installation of Lightning Protection Systems |
| 17. | ASME A17.1 | 1993 | Elevator Code |
| 18. | Americans with Disabilities Accessibility Guidelines - 1998 | | |

19. ANSI A117-1 1998 Accessibility Code
20. AMCA 210 Laboratory Methods of Testing Fans for Rating Purposes
(latest edition)
21. AMCA 310 Reverberant Room Method for Sound Testing of Fans
(latest edition)
22. AMCA 500 Test Method for Louvers, Dampers, and Shutters
(latest edition)
23. ARI 410 Forced-Circulation Air-Cooling and Air Heating Coils
(latest edition)
24. SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC
(latest edition) Systems, Sheet Metal and Air Conditioning Contractors National Association, Inc.
25. Florida Accessibility Code for Building Construction – 2001 Edition with 2003 Revisions
26. Florida Building Code – 2014
27. Florida Building Code, Mechanical – 2014
28. Florida Building Code, Plumbing – 2014
29. Florida Building Code, Gas – 2014
30. Florida Building Code, Test Protocols for High Velocity Hurricane Zones – 2014
31. Florida Building Code, Florida Energy Efficiency for Building Construction – 2014
32. The Guidelines for Design and Construction of Hospitals and Health Care Facilities – 2013 Edition

- I. Secure and pay for all permits and inspections required by any of the Authorities Having Jurisdiction (AHJ).

1.12 GUARANTEE AND 24 HOUR SERVICE

- A. Guarantee the Work of this Section in writing for one year following the date of Substantial Completion. If the equipment is used for ventilation, temporary heat, etc. prior to initial beneficial occupancy by the Owner, the bid price shall include an extended period of warranty covering the one-year of occupancy, starting from the initial date of beneficial occupancy by the Owner. The guarantee shall repair or replace defective materials,

equipment, workmanship and installation that develop within this period, promptly and to Architect's satisfaction and correct damage caused in making necessary repairs and replacements under guarantee within Contract Price.

- B. In addition to guarantee requirements of Division 1 and of Paragraph A above, obtain written equipment and material warranties offered in manufacturer's published data without exclusion or limitation, in Owner's name.
- C. Replace material and equipment that require excessive service during guarantee period as defined and as directed by Architect.
- D. Provide 24-hour service beginning on the date of Substantial Completion and lasting until the termination of the guarantee period. Service shall be at no cost to the Owner. This contractor or a separate service organization can provide Service. Choice of service organization shall be subject to Architect and Owner approval. Submit name and a phone number that will be answered on a 24-hour basis each day of the week, for the duration of the service.
- E. Submit copies of equipment and material warranties to Architect as part of the close-out documents before final payment.
- F. At end of guarantee period, transfer manufacturers' equipment and material warranties still in force to Owner.
- G. This Article shall not be interpreted to limit Owner's rights under applicable codes and laws and under this Contract.
- H. Specific Paragraphs of the Specification sections may specify warranty requirements that exceed those of this Article.
- I. Use of systems provided under Divisions 21, 22, 23 and 26, 27 for temporary services and facilities shall not constitute Final Acceptance of work nor beneficial use by Owner, and shall not institute guarantee period.
- J. Provide manufacturer's engineering and technical staff at site to analyze and rectify problems that develop during guarantee period immediately. If problems cannot be rectified immediately to Owner's satisfaction, advise Architect in writing, describe efforts to rectify situation, and provide analysis of cause of problem. Architect will suggest course of action.

1.13 RECORD DOCUMENTS

- A. As work progresses and for duration of Contract, maintain a complete and dedicated set of Contract Documents (including drawings and specifications) at the job site at all times, to become the Record Documents. Record work completed and all changes from original Contract Documents clearly and accurately, including work installed as a modification or addition to the original design. This shall be updated, at a minimum weekly, and will be reviewed prior to each Pay Application approval.
- B. Take photographs of all concealed equipment in gypsum board ceilings, shafts, underground (buried) piping routes and supports and other concealed, inaccessible work.

At completion of work, make copies of photographs with written explanation for each photo. These shall become part of Record Documents.

- C. Underground and utility work shall be located by distances to landmarks, such as building foundations. Give actual dimensions of everything installed including elevations and elevations at each change in direction.
- D. Drawings shall also show record condition of details, sections, riser diagrams, control changes and corrections to schedules. Schedules shall incorporate actual manufacturer and make and model numbers of final equipment installation.
- E. THE ENGINEER/ARCHITECT WILL NOT CERTIFY THE ACCURACY OF THE RECORD DRAWINGS - THIS IS THE SOLE RESPONSIBILITY OF THE CONTRACTOR.
- F. When required by the jurisdiction, each trade shall submit the record set for approval by the building department in a form acceptable to the department. Any document format size changes, and supplemental information required for the submittal are the responsibility of the contractor.
- G. The Record Documents shall include at a minimum:
 - 1. Actual location of existing utilities.
 - 2. Field changes to installation that differ from original design documents.
 - 3. Document revisions associated with RFI responses, Supplemental Instructions, Proposal Requests, and Change Orders, etc.
 - 4. Show routing of electrical feeder conduits.
 - 5. Show power and lighting circuiting indicating actual panel and circuit number.
- H. Quality of Record Documents shall equal or exceed that of original Contract Documents.
- I. The record documents shall be submitted in electronic media format to the Architect/Engineer for review and approval, prior to Application for Final Payment.
- J. Obtain at time of purchase of equipment, three copies of operation, lubrication and maintenance manuals for all items. Assemble literature in coordinated manuals with additional information describing combined operation of field assembled units, including as-built wiring diagrams. Manual shall contain names and addresses of manufacturers and local representatives who stock or furnish repair parts for items or equipment. Divide manuals into three sections or books as follows:
 - 1. Directions for and sequence of operation of each item of the Mechanical and Electrical systems, e.g., air handling units, boilers, domestic water pump, generator, etc. Sequence shall list valves, switches and other devices used to start, stop and control system. Detail procedure to be followed in case of malfunctions. Include detailed approved flow diagrams of temperature control, heating, condensate, chilled water, condenser water, etc., as appropriate for systems

- provided. Include approved valve directory showing each valve number, location of each valve, and equipment or fixture controlled by valve.
2. Detailed maintenance and troubleshooting manuals containing data furnished by manufacturer for complete maintenance. Include copy of Engineer-approved balancing report.
 3. Lubrication instructions detailing type of lubricant, amount, and intervals recommended by manufacturer for each item of equipment. Include additional instructions necessary for implementation of first class lubrication program. Include approved summary of lubrication instructions in chart form, where appropriate.
- K. The manuals shall include the following and shall have an index of contents and tabs for each Specification Section and each piece of equipment specified in that Section and be provided in the order listed below, per Specification Section.
1. Copies of all approved submittals/shop drawings.
 2. Manufacturer's operating and maintenance instructions and parts lists of all items or equipment. Where manufacturer's data includes several types or models, the applicable type or model shall be clearly designated.
 3. Startup and shutdown procedures.
 4. Flow diagrams.
 5. Test records.
 6. Wiring diagrams.
 7. Composite electrical diagrams.
 8. Owner's written acknowledgement of satisfactory completion of instruction period.
- L. The operation manuals and instructions to the Owner are of prime importance and shall be provided prior to request for final payment.
- M. Furnish three copies of manuals to Architect for approval 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.
- N. Provide framed and glazed charts as follows (mount as directed by Owner or Architect):
1. Flow diagrams from first part of manual as described above.
 2. Valve directory.
 3. Lubrication chart from third part of manual.

- O. Operating instructions: Upon completion of installation or when Owner accepts portions of building and equipment for operational use, instruct Owner's operating personnel in any or all parts of all systems. Factory-trained personnel shall perform instructions. Owner shall determine which systems require additional instructions. Duration of instructions shall take equipment through complete cycle of operation (at least five working days). Make adjustments under operating conditions.

1.14 PROTECTION OF WORK

- A. Each contractor shall be responsible for his work and equipment until finally inspected, tested, and accepted. Carefully store materials and equipment, which are not immediately installed after delivery to site. Close open ends of work with temporary covers or plug during construction to prevent entry of obstructing material.
- B. Each separate contractor shall protect the work and material of other trades that might be damaged by his work or workmen and make good all damage thus caused.

1.15 SUBMITTALS

- A. This Article supplements Division 1.
- B. Definitions:
 - 1. Shop Drawings are information prepared by the Contractor to illustrate portions of the work, such as ductwork layout arrangements, in more detail than shown in the Contract Documents.
 - 2. Coordination Drawings are detailed, large-scale layout Shop Drawings showing HVAC, Electrical, Plumbing and Fire Protection work superimposed in order to identify conflicts and ensure inter-coordination of Mechanical, Electrical, Architectural, Structural and other work.
 - 3. Submittals are a compilation of product data cutsheets fully describing performance, size, connections, color selection, etc., as provided by the manufacturer.
- C. Submittal Cover Sheet
 - 1. Submittal data for each product shall include a copy of the following cover sheet completely filled out. Incomplete or incorrect cover sheet submittal shall constitute reason for rejection.
 - 2. Shop drawings/submittals shall be submitted according to applicable specification section's requirements with a separate cover sheet completed for each product, rather than one cover sheet for multiple products, whether or not supplied by one manufacturer or vendor.
 - 3. Review submittal packages for compliance with Contract Documents and then submit to Architect for review. Submit reproducible drawing and two blue- or black-line reproductions of each Shop Drawing larger than 8-1/2 x 11. Submit four sets of each smaller shop drawing. After review, reproducible original of each large

Shop Drawing and three sets of each small shop drawing will be returned with reviewer's marks.

4. Submittals and shop drawings shall be submitted COMPLETE, by trade, in heavy-duty three-ring binders. Each binder shall include a Table of Contents identifying each section. Each section shall be arranged in order of specification section and tabbed accordingly. Each item submitted shall reference the article and paragraph of its specification section. Each item specified shall be addressed. If specified item will not be used, state so in submittal with brief explanation. (Example: Globe Valves - N/A, use ball and butterfly valves.) In the instance when a resubmission is necessary, resubmit only the items required; a complete resubmittal containing previously approved data is not required.
5. Submittals and/or shop drawings associated with long lead items required on this project, shall be submitted within 30 days after Notice to Proceed has been issued.
6. Provide additional copies of approved submittals/shop drawings as required for full distribution.
7. Shop Drawings showing layouts of systems shall contain sufficient plans, elevations, sections, details and schematics to describe work clearly. They shall be 1/4 inches = 1 foot 0 inch scale unless specified otherwise. Sheet Metal Shop Drawings shall be 3/8 inch = 1 foot 0 inch and shall indicate work of other Sections where physical clearances are critical and where interferences are possible. Provide larger scale details as necessary. Sheet Metal Drawings shall show elements of Architect's reflected ceiling plan, exposed ductwork, walls, partitions, diffusers, registers, grilles, fire dampers, sleeves and other aspects of construction as necessary for coordination. Submit one reproducible plus two prints of each shop drawing.
8. ALL FIREWALLS AND SMOKE PARTITIONS MUST BE HIGHLIGHTED ON THE SHEETMETAL DRAWINGS FOR APPROPRIATE COORDINATION.
9. Shop drawings and submittals showing manufacturer's product data shall contain detailed dimensional drawings, accurate and complete description of materials of construction, manufacturer's published performance characteristics and capacity ratings (performance data, alone, is not acceptable), electrical requirements and wiring diagrams. Drawings shall clearly indicate location (terminal block or wire number), voltage and function for all field terminations, and other information necessary to demonstrate compliance with all requirements of Contract Documents.
10. Provide shop drawing submittals showing details of piping connections to ALL equipment. If connection details are not submitted and connections are found to be installed incorrectly in the field, this contractor shall reinstall them within the original contract price.

D. Acceptable Manufacturers

1. The Engineer's mechanical/electrical design for each product is based on the manufacturer listed in the schedule or shown on the drawings. In Part 2 of the specifications certain Alternate Manufacturers are listed as being acceptable. The listing of a manufacturer as acceptable does not imply automatic approval. It is the sole responsibility of the Contractor to ensure that any submittals made are for products that meet or exceed the specifications included herein. These are acceptable only if, as a minimum, they:
 - a. Meet all performance criteria listed in the schedules and outlined in the specification. For example, to be acceptable, an air-handling unit must deliver equal CFM against equal external static pressure using equal or fewer horsepower as the air handler listed in the schedules.
 - b. Have identical operating characteristics to those called for in the specification. For example, a two-stroke diesel generator will not be acceptable if a four-stroke model is specified.
 - c. Fit within the available space it was designed for, including space for maintenance and component removal, with no modification to either the space or the product. Clearances to walls, ceilings and other equipment will be at least equal to those shown on the design drawings. The fact that a manufacturer's name appears as acceptable shall not be taken to mean that the Engineer has determined that the manufacturer's products will fit within the available space - this determination is solely the responsibility of the contractor.
 - d. For rooftop mounted equipment and for equipment mounted in areas where structural matters are a consideration, the products must have a weight no greater than the product listed in the schedules or specifications.
 - e. Products must adhere to all architectural considerations including but not limited to: being of the same color as the product scheduled or specified, fitting within architectural enclosures and details, and for diffusers, lighting and plumbing fixtures - being the same size and of the same physical appearance as scheduled or specified products.
 - f. All equipment shall be labeled or listed by the National Board of Underwriters Laboratories (U.L.) where such labeling or listing exists for such material.

E. Required Use of Acceptable Manufacturers on this Project:

1. Substitution of products other than those of the Acceptable Manufacturers specified herein shall not be made. Only the specified items or the comparable product by one of the specified Alternate Manufacturers shall be submitted. Products by other manufacturers shall not be used on this project.

2. Listing of a manufacturer's name for a particular material or piece of equipment does not imply acceptance of all of that manufacturer's products. Use of more than one manufacturer to supply any specific material or equipment shall have prior approval of the Architect/Engineer.

F. Deviations

1. Concerning deviations other than substitutions, proposed deviations from Contract Documents should be requested individually in writing whether deviations result from field conditions, standard shop practice, or other cause. Submit letter with transmittal of submittals/shop drawings which flags the deviation to the attention of the Architect.
2. Without letters flagging the deviation to the Architect, it is possible that the Architect may not notice such deviation or may not realize its ramifications. Therefore, if such letters are not submitted to the Architect, the contractor shall hold the Architect and his consultants harmless for any and all adverse consequences resulting from the deviations being implemented. This shall apply regardless of whether the Architect has reviewed or approved submittals/shop drawings containing the deviation, and will be strictly enforced.
3. Approval of proposed deviations, if any, will be made at the discretion of the Architect.
4. Where equipment or methods different than those specified are submitted by this Contractor and approved for use by the Engineer and Owner, the installation shall be in full conformance with the intent of these Contract Documents. All costs related to the use of the different method and/or equipment shall be paid by this Contractor.

G. Submittal Dispositions: Submittals will be returned from the Engineer marked as illustrated below:

APPROVED -	Submitted data is in compliance with Contract Document requirements; item is approved for release.
APPROVED AS NOTED -	Submitted data is generally in compliance with Contract Document requirements with minor notations; no resubmission required. Item is approved for release if engineers' notations are addressed.
NOT APPROVED -	Submitted data in no way complies with Contract Document requirements; resubmission of specified manufacturer or equipment is required. Item is not approved for release.
REVISE AND RESUBMIT -	Submitted data contains deviations, is incomplete, or requires further clarification any of which require resubmission for confirmation; item is not approved for release.

NOT REVIEWED -

Submitted data is not required to be submitted for Engineer's approval or was incorrectly transmitted to the Engineer for review and approval.

H. Responsibility

1. Intent of Submittal review is to check for capacity, rating, and certain construction features. Contractor shall ensure that work meets requirements of Contract Documents regarding information that pertains to fabrication processes or means, methods, techniques, sequences and procedures of construction; and for coordination of work of this and other Sections. Work shall comply with submittal notations to extent that they agree with Contract Documents. Submittal review shall not diminish responsibility under this Contract for dimensional coordination, quantities, installation, wiring, supports and access for service, nor shop drawing errors or deviations from requirements of Contract Documents. The Architect's/Engineer's noting of some errors while overlooking others will not excuse the Contractor from proceeding in error. Contract Documents requirements are not limited, waived nor superseded in any way by review.

2. INFORM SUBCONTRACTORS, MANUFACTURERS, SUPPLIERS, ETC., OF SCOPE AND LIMITED NATURE OF REVIEW PROCESS AND ENFORCE COMPLIANCE WITH CONTRACT DOCUMENTS.

a. The Engineer's obligations to review shop drawings and other submittals and to return them in a timely manner are conditioned upon the prior review and approval of the shop drawings or submittals by the Contractor as required in the construction contract and the Contractor's submittal of the shop drawings and other submittals in accordance with a written schedule distributed in advance to the Engineer identifying the dates for the submittal of the various shop drawings and submittals.

I. Schedule: Incorporate submittal review period into construction schedule so that Work is not delayed. Contractor shall assume full responsibility for delays caused by not incorporating the following submittal review time requirements into his project schedule. Working days listed reference the time in the Engineer's office. It does not include transmittal or review time of Contractor or Architect. If more than five submittals/shop drawings of a single trade are received in one week, allow at least five (5) additional working days, exclusive of transmittal time, for review, each time a submittal/shop drawing is submitted or resubmitted.

J. Multiple Re-submittals: The Engineer will review the first submittal from the contractor and respond with comments, and will review one re-submittal for the same item(s) from the contractor and respond with comments. If the contractor is required to make subsequent submittals for the same item(s) the Engineer shall be compensated by the contractor for the time to review each subsequent re-submittal. The contractor shall agree to compensate the Engineer a minimum of \$500 per each re-submittal item.

1.16 UTILITY COSTS

- A. The Contractor shall include all costs from the electrical, water, sewer, gas, etc., utility companies that are assessed the Owner for installation of these services. It is the responsibility of the Contractor to obtain these costs from the utility companies and include them in his Bid.

1.17 TEMPORARY/CONTINUITY OF UTILITY SERVICES

- A. Refer to Division 1 - General Requirements, regarding specific requirements.
- B. Provide temporary services where project construction schedule requires extended shut downs of existing equipment and/or systems. Temporary services include the necessary equipment and/or systems to maintain continuity of services. Extended shut downs are interruptions of existing services for a period of time longer than that acceptable to the Owner.
- C. Coordinate work under Divisions 21, 22, 23 and 26, 27 with progress of construction so that permanent-heating/cooling system will be ready to provide temporary heating/cooling if permitted by Architect as soon as building is closed in.
- D. Provide and direct labor required for attendance, operation and final restoration of permanent heating/cooling system if used for temporary heating/cooling purposes. Owner shall provide continuous direct attendance whenever permanent system is in operation prior to acceptance of permanent heating/cooling system.
- E. Heating, air conditioning, humidity control and any other environmental factors shall be the responsibility of the Contractor throughout the construction period.
- F. Do not interrupt existing utility services without written Owner's approval.
- G. Schedule interruptions in advance, according to Owner's instructions. Submit, in writing, with request for interruption, methods proposed to minimize length of interruption.
- H. Interruptions shall be scheduled at such times of day and work so that they have minimal impact on Owner's operations.
- I. Contractor shall coordinate any shutdowns of existing systems as follows:
 - 1. Give proper notice to Owner when making shutdowns; a minimum of fourteen full days is required.
 - 2. Minimize timeline of shutdowns of any system.
 - 3. Provide temporary services where required and perform shutdowns and tie in's at a time convenient to Owner.
 - 4. Contractor shall be responsible for completing and filing the Owner's shutdown notice questionnaire.
 - 5. Perform required survey and inspection work required by the notice for shutdown.

- 6. All life safety systems, including but not limited to automatic sprinklers, shall be returned to service at the end of each work day, when work is being performed on the systems. It is the responsibility of the Contractor to provide all associated appurtenances necessary to ensure that the systems are in proper working condition at all times.
- J. Provide all necessary material, tools, and labor as required for the provisions of temporary services.
- K. Include premium time work associated with interruptions of services and/or shutdowns as necessary to avoid disruption to Owner's operations.
- L. For electrical work associated with Primary power, coordinate with the Electrical Power Utility Company.
- M. Complete the following form, indicating what is being included as part of this bid, and this project.
- N. For work involving an independent utility company (i.e., non-owner provided utility), Contractor shall coordinate directly with the utility provider all aspects of related work, including shutdowns, tie-ins, capacity impacts, etc.

PART 2 -PRODUCTS

2.1 GENERAL

- A. Refer to each specific Mechanical and Electrical section for specific details.

PART 3 -EXECUTION

3.1 SPECIAL RESPONSIBILITIES

- A. Cooperate and coordinate with work of other Sections in executing work of Divisions 15 and 16.
 - 1. Perform work such that progress of entire project including work of other Sections shall not be interfered with or delayed.
 - 2. Provide information as requested on items furnished under Divisions 15 and 16 which shall be installed under other Sections.
 - 3. Obtain detailed installation information from manufacturers of equipment provided under Divisions 15 and 16.
 - 4. Obtain final rough-in dimensions or other information as needed for complete installation of items furnished under Divisions 15 and 16 or by Owner.
 - 5. Keep fully informed as to shape, size and position of openings required for material or equipment to be provided under Divisions 15 and 16 and other Sections. Give full information so that openings required by work of Divisions 15 and 16 may be

coordinated with other work and other openings and may be provided for in advance. In case of failure to provide sufficient information in proper time, provide cutting and patching or have same done, at own expense and to full satisfaction of Architect.

6. Provide information as requested as to sizes, number and locations of concrete housekeeping pads necessary for floor-mounted vibrating and rotating equipment provided under Divisions 15 and 16.
7. Notify Architect of location and extent of existing piping, conduit, ductwork and equipment that interferes with new construction. In coordination with and with approval of Architect, relocate piping, ductwork and equipment to permit new work to be provided as required by Contract Documents. Remove non-functioning and abandoned piping, ductwork and equipment as directed by Architect. Dispose of or store items as requested by Architect.

B. Installation Only Items:

1. Where this Contractor is required to install items which he does not purchase, he shall coordinate their delivery and be responsible for their unloading from delivery vehicles and for their safe handling and field storage up to the time of installation. These trades shall be responsible for:
 - a. Any necessary field assembly and internal connections, as well as mounting in place of the items, including the purchase and installation of all dunnage supporting members and fastenings necessary to adapt them to architectural and structural conditions.
 - b. Their connection to building systems including the purchase and installation of all terminating fittings necessary to adapt and connect them to the building systems.
2. This Contractor shall carefully examine such items upon delivery. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable scope of work of this Contractor will be considered only if presented in writing within one week of their date of delivery. Unless such claims have been submitted, this Contractor shall be fully responsible for the complete reconditioning or replacement of the damaged items.

C. Maintenance of equipment and systems: Maintain equipment and systems until Final Acceptance. Ensure adequate protection of equipment and material during delivery, storage, installation and shutdown and during delays pending final test of systems and equipment because of seasonal conditions.

D. Use of premises: Use of premises shall be restricted as directed by Architect and as noted below.

1. Remove and dispose of dirt and debris, and keep premises clean. During progress of work, remove equipment and unused material. Maintain building and premises in neat and clean condition, and perform cleaning and washing required to provide acceptable appearance and operation of equipment, to satisfaction of Architect.

2. Store materials in a manner that will maintain an orderly, clean appearance. If stored on-site in open or unprotected areas, all equipment and material shall be kept off the ground by means of pallets or racks, and covered with tarpaulins.
3. Do not interfere with function of existing sewers and water and gas mains, electrical or mechanical systems and services. Extreme care shall be taken to prevent debris from entering pipe, ductwork and equipment. Confer with Architect as to disruption of services or other utilities due to testing or connection of new work to existing. Interruption of services shall be performed at time of day or night deemed by Owner to provide minimal interference with normal operation. Obtain Owner's approval of the method proposed for minimizing service interruption.

E. Surveys and measurements:

1. Base measurements, both horizontal and vertical, on reference points established by Contractor and be responsible for correct laying out of work.
2. Ensure clearances between all underground utilities comply with code and Authority Having Jurisdiction.
3. Prior to installation of underground utilities which connect to site utilities provided by others, verify all existing invert elevations.
4. In event of discrepancy between actual measurements and those indicated, notify Architect in writing and do not proceed with work until written instructions have been issued by Architect.

F. Fireproofing:

1. Clips, hangers, clamps, supports and other attachments to surfaces to be fireproofed shall be installed, insofar as possible, prior to start of spray fiber work.
2. Ducts, piping and other items, which would interfere with proper application of fireproofing, shall be installed after completion of spray fiber work.
3. Patching and repairing of fireproofing due to cutting or damaging to fireproofing during course of work specified under this Section shall be performed by installer of fireproofing and paid for by trade responsible for damage and shall not constitute grounds for extra cost to Owner.

G. Airbound Systems

1. If, after plant is in operation, any piping systems, coils or other apparatus are stratified or air bound (by vacuum or pressure), they shall be re-piped with new approved and necessary fittings, air vents, or vacuum breakers at no extra cost to the Owner. If connections are concealed in furring, floors, or ceilings, this trade shall bear all expenses of cutting, patching and refinishing construction and finish, leaving same in as good condition as before it was disturbed.

H. Miscellaneous

1. Unload materials and equipment delivered to site. Pay costs for rigging, hoisting, lowering and moving mechanical and/or electrical equipment on and around site,
2. to correct the deficiency with his own forces and back charge this Contractor.

3.2 MATERIALS AND WORKMANSHIP

- A. Work shall be neat and rectilinear. Ductwork, piping, conduit, etc., shall run concealed except in mechanical rooms and areas where no hung ceiling exists. Install material and equipment as required by manufacturers. Installation shall operate safely and without leakage, undue wear, noise, vibration, corrosion or water hammer. Work shall be properly and effectively protected, and pipe and duct openings shall be temporarily closed to prevent obstruction and damage before completion.
- B. Except as specified otherwise, material and equipment shall be new. Provide supplies, appliances and connections necessary for complete and operational installation.
- C. Finish of materials, components and equipment shall be as approved by Architect and shall be resistant to corrosion and weather as necessary.
- D. Owner will not be responsible for material and equipment before testing, commissioning, and acceptance.

3.3 WELDING

- A. Weld only by approved acetylene or electric welding processes and welders shall hold certificate from approved insurance company.
- B. Conduct test to demonstrate suitability of procedures to be used in making welds, which conform to specified requirements.
- C. Specification for welding procedure shall meet requirements of Welding Qualifications, Section IX, ASME Boiler and Pressure Vessel Code and ANSI B31.1.
- D. Align components. No strain shall be placed on weld during welding. No part of pipe shall be offset more than 20% of thickness. Set flanges and branches properly.
- E. Welder and Brazing Qualification:
 1. Test welders to demonstrate ability to make acceptable welds. Tests conducted for qualification of welder for work under one Division or Section shall not necessarily qualify welder for work under another Division or Section.
 2. Tests shall be as prescribed for welder qualification in Section IX of the ASME code.
 3. Records of such tests shall be as follows: Each welder shall be assigned an identifying number, letter or symbol. Identifying mark shall be stamped adjacent to welds made by this welder. Identification shall be at top of horizontal piping and at front of vertical piping.

4. Maintain record of welders employed, showing dates and results of tests and identifying mark assigned to each welder. Certify records and make them accessible to Owner's project representative and/or project manager. Before completion of project, one copy of records shall be turned over to Owner.
5. No qualification shall be older than three years when welder commences work on this project. If welder has not welded in required welding process for a period of six months, he shall be re-certified.

F. Welding Tests

1. As designated by Architect, remove welds for destructive testing or for testing by non-destructive means. Tests shall be as determined by Architect.
2. If, in Architect's opinion, welds so tested do not meet requirements of Sections VIII and IX of ASME, then the Contractor shall pay for the costs of the tests. Remove welds welded by that welder, at no cost to the Owner. Rewelding shall be performed by qualified welder other than welder whose welds did not pass test. Welders whose welds were defective shall not be employed on site for remainder of project.
3. Welding of stanchions, brackets, anchors and other welding not performed on pipe joints shall be in accordance with requirements of AWS specifications and requirements.

3.4 CEILING ACCESS AND ACCESS PANELS

- A. Access panels are generally not shown on the drawings, but they are required to be provided by Contractor.
- B. Provide proper access to materials and equipment that require inspection, replacement, repair or service, and coordinate their delivery with the installing Trade. If proper access cannot be provided, confer with Architect as to best method of approach for minimizing effect of reduced access which may result.
- C. The maximum distance from the ceiling line to serviceable equipment (i.e., air terminal boxes, valve handles, volume damper handles, etc.) shall be 24 inches unobstructed, unless otherwise noted on the drawings.
- D. Coordinate and prepare a location, size, and function schedule of access panels required to fully service equipment and deliver to a representative of the installing Trade. Furnish and install distinctively colored buttons (color as selected by Architect) in finished ceiling to identify all access panels.
- E. Ceilings consisting of lay-in or removable splined tiles do not require access panels. Fire, control dampers, valves and equipment located above ceiling shall have location marked with color-coded identification screws attached to the ceiling "grid." Location shall be noted on record drawings.
- F. Furnish access panels for installation under other Sections where fire dampers, volume dampers, controls, shut-off valves, control valves, check valves, or other items installed

under Divisions 15 and 16 require access and are concealed in floor, wall, furred space or above ceiling. Access panels shall be by Milcor, Knapp, Nystorm or Inland Steel; coordinate selection with other Sections supplying similar access panels. Color of panel shall be selected by the Architect.

- G. Access panels shall have same fire rating classification as surface penetrated. Rated access panels must have U.L. Label.
- H. Panels shall be at least 12 inches x 12 inches; access panels at equipment (VAV boxes, fan boxes and others) shall be at least 18 inches x 18 inches.

3.5 PENETRATIONS AND SLEEVES

A. General

1. Lay out penetration and sleeve openings in advance, to permit provision in work. Set sleeves and conduit in forms before concrete is poured. Provide remedial work where sleeves and conduits are omitted or improperly placed.
2. Provide sleeves and packing materials at all penetrations of foundations, walls, slabs (except on-grade), partitions and floors. Sleeves shall meet U.L. rated assemblies requirements and materials requirements of these specifications.
3. Sleeves that penetrate outside walls, basement slabs, footings and beams shall be waterproof.
4. Coordinate work carefully with architectural and structural work. Provide core drilling as necessary if walls are poured, or otherwise constructed, without sleeves and a wall penetration is required. Provide core drilling as required for penetrations of existing construction. Do not penetrate structural members without Structural Engineer's/Architect's approval.
5. Sleeves for insulated pipe and duct in non-fire rated construction shall accommodate continuous insulation without compression. Sleeves and/or penetrations in fire rated construction shall be packed with fire rated material which shall maintain the fire rating of the wall. Seal ends of penetrations to provide continuous vapor barrier where insulation is interrupted.
6. Submit a list of the U.L. Listed details that the Contractor intends on using on this project, in all rated walls.
7. Where pipes, etc., passing through openings are exposed in finished rooms, finishes of filling materials shall match and be flush with adjoining floor, ceiling, and wall finishes.
8. Identify unused sleeves and slots for future installation.
9. Fill slots, sleeves and other openings in floors or walls if not used. Fill spaces in openings after installation of pipe, duct, conduit or cable.

10. Fill for floor penetrations shall prevent passage of water, smoke, fire, and fumes. Fill shall be fire resistant in fire floors and walls, and shall prevent passage of air, smoke and fumes.
11. Sleeves through floors shall be watertight and shall extend 2 inches above floor surface.
12. Submit and coordinate with all trades complete penetration layout drawings showing all openings in building structural members including floor slabs, walls, bearing walls, foundation walls, shear walls, roof penetrations, etc. Indicate and locate, by dimension, all openings that shall be sleeved. Drawings shall be approved by Structural Engineer prior to the preparation of any opening in a structural member. Provide 24 gauge galvanized steel sleeves for all walls, floors, including foundation, stem and exterior walls.
13. All penetrations into libraries, auditoriums, conference rooms, sleep rooms, etc., must utilize an acoustical sealant in addition to any other sealants required for wall ratings.
14. Contractor shall maintain complete integrity of all completed waterproofing, weatherproofing, fire rating, and penetrations during construction.

B. Pipe and Conduit Sleeves

1. Annular space between pipe/conduit and sleeve shall be at least 1/4 inch.
2. Sleeves are not required for slabs-on-grade unless specified otherwise.
3. Sleeves and packing materials, through rated firewalls and smoke partitions, shall maintain fire rating of construction penetrated.
4. Do not support piping risers or conduit on sleeves.
5. Where pipe penetrations occur through exterior walls into building spaces, use steel pipe sleeves with integral water stop, type "WS" wall sleeves by Thunderline Corporation or approved equal. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation, or sealing system by another manufacturer approved as equal by Architect. Where "Link-Seals" are used with insulated pipes, butt insulation against seals on both sides.
6. Penetrations through gypsum board walls do not require flexible couplings and/or sleeves. Where flexible couplings are used through non-frangible walls, provide one coupling on each side of the wall penetrated, within 1 foot from the face of the wall.

C. Duct Sleeves and Prepared Openings

1. Provide duct sleeves for round ducts 15 inches and smaller; provide prepared, framed openings for round ducts larger than 15 inches and for square, rectangular

and flat oval ducts, except as specified otherwise. Sleeves shall meet SMACNA requirements.

2. Provide sleeves for ducts through 1-, 2- or 3-hour fire-rated construction and smoke partitions, regardless of size and shape of ducts. Sleeves shall maintain fire rating of construction penetrated. Sleeve and seal materials, construction and clearances shall meet requirements of SMACNA Fire Damper and Heat Stop Guide for Air Handling Systems.
3. Prepared openings shall be framed to provide 1 inch clearance between framing and duct or duct insulation in non-rated partitions.
4. All duct penetrations through concrete floors in mechanical rooms shall have 2 inches high water stopped curbs surrounding the openings. This applies to mechanical rooms above the lowest floor level.
5. Trim duct penetrations exposed in finished areas with 2 inches wide galvanized or aluminum trim collars properly sized to fit the duct. Collars to be same gauge as duct, prime finish unless noted otherwise. Finished areas shall not include mechanical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.

D. Installation Testing, Listings and Approvals

1. Installation shall meet material manufacturer's recommendations exactly, particularly regarding safety, ventilation, removal of foreign materials and other details of installation. Dam openings as recommended. Remove flammable materials used for damming and forming seals in fire-rated construction.
2. Sleeve penetration methods shall be water- and gas-tight and shall meet requirements of ASTM E-119 Standard Methods of Fire Tests of Building Construction and Materials.
3. Fire-stop penetration seal methods and materials shall be FM-approved and UL-listed as applicable.
4. Inspect foamed sealant to ensure manufacturer's optimum cell structure and color ranges.
5. A quality assurance program for the installation of devices and systems installed to protect penetration and joints shall be prepared and monitors by the RDP responsible for design. Inspections of firestop systems and fire resistive joint systems shall be in accordance with 12.3.2.1 and 12.3.2.2.

3.6 ANCHORS AND INSERTS

- A. Provide anchors as necessary for attachment of equipment supports and hangers. Anchors shall be iron or steel inserts of type to receive machine bolt head or nut after installation.
- B. Inserts shall permit adjustment of bolt in one horizontal direction and shall develop strength of bolt when installed in properly cured concrete.

- C. Inserts drilled and spaced after concrete pour shall be steel shell with plug type, not depending on soft lead for holding power.

3.7 EQUIPMENT SUPPORTS AND GUARDS

- A. Provide all supporting steel not indicated on the structural drawings as required for the installation of equipment and materials, including angles, channels, beams, hangers, etc. Do not support equipment or piping from metal decking.
- B. Provide equipment guards over belt driven assemblies, pump shafts, exposed fans and elsewhere as indicated in this specification or required by code.
- C. Where guards are not furnished factory made or integral with equipment, they shall be constructed by the Contractor.

3.8 ESCUTCHEONS

- A. Install escutcheons around exposed pipe passing through finished floor, floor, wall, or ceiling. Escutcheons shall be heavy cast brass, chromium-plated, adjustable, and shall be of sufficient outside diameter to cover sleeve opening and shall fit snugly around pipe and flush against floor or wall surface.

3.9 CORE DRILLING

- A. Core drilling is to be avoided.
- B. Set sleeves prior to installation of structure for passage of pipes, conduit, ducts, etc.
- C. Where core drilling is unavoidable, or required by renovation projects, locate all required openings prior to coring and submit to Architect for review.
- D. Coordinate openings with General Contractor/Construction Manager and all other trades.
- E. Core drilling is to be provided by the Contractor for General Construction, not by the M/E subcontractors.
- F. Do not disturb existing systems. Protect all areas from damage of any type.
- G. Thoroughly investigate existing conditions in vicinity of required opening prior to coring.

3.10 MISCELLANEOUS TESTING AND BALANCING

- A. Tests for piping systems and equipment shall be performed as specified in their respective specification sections.
- B. No part of any underground work shall be covered until after it is inspected, tested, approved, and photographed.
- C. Provide all equipment required for testing, including fittings for additional openings as required.

- D. Notify the Architect and any Inspectors required to observe the test, at least 48 hours prior to when the test is ready to be performed.
- E. The General Contractor is responsible for certifying in writing, the results of all testing of systems and equipment in this contract. These written results will be required at project close-out.
- F. Include description and what portion of the system has been tested. Record date, time, test medium and pressure used, name and title of the person certifying the test. This person shall sign the certification. Forms and data must be legible.
- G. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary, and repeat the inspection and test. Make repairs with new materials. No caulking of holes or screwed joints will be allowed.
- H. Maintain complete records at the job site of all testing that has been certified. At completion of the project, include in the instruction manuals clearly legible copies of all test approval records and certification.
- I. Balancing of the various systems shall be in accordance with those specific balancing specification sections.
- J. Balance the entire new water distribution system. Set all balancing valves for proper flow control of all circulating water.
- K. All flushing valves, pressure regulating valves, or other regulating devices shall be adjusted for proper balancing and flow to the plumbing fixture and/or equipment.
- L. If the exterior domestic water supply is also serving as a source for fire protection, either exterior or interior or both, it shall be tested according to the fire protection system as herein specified.

3.11 ELECTRICAL TESTS

- A. Contractor shall be responsible for all equipment required for testing.
- B. On completion of work all systems installed shall test entirely free of grounds and short circuits. Before the systems are energized, perform continuity test to insure proper cable connection. Perform insulation-resistance test on each feeder conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts dc for 1 minute for 480 volt equipment and 500 volts dc for 1 minute for 120 and 208 volt equipment. Evaluate results by comparison with cables of same length and type. Investigate values less than 50 megohms. Provide test report to the Engineer. Include copies of all test results in the Operation and Maintenance Manuals.
- C. Feeder unbalance measurements shall be made after the systems are in normal use by the Owner. All unbalance greater than 10% shall be corrected by this Contractor.
- D. Grounding system in patient care areas shall be tested in accordance with NFPA 99 requirements. The effectiveness of the grounding system shall be determined by voltage measurements and impedance measurements and shall include all receptacles and metal

conductive surfaces likely to become energized within the patient vicinity. Provide test report to the Engineer using the attached form.

- E. Receptacle testing in patient care areas shall include the following:
 - 1. The physical integrity of each receptacle shall be confirmed by visual inspection.
 - 2. The continuity of the grounding circuit in each receptacle shall be verified.
 - 3. Correct polarity of the hot and neutral connections in each receptacle shall be confirmed.
 - 4. The retention force of each electrical receptacle shall be not less than 115 grams (4 oz.).

3.12 DELIVERY, STORAGE AND HANDLING

- A. Protect equipment/materials from damage during shipping, storage, handling and installation. Delivery equipment/materials to the site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.
- B. The Contractor shall provide for enclosed storage, when equipment/materials are stored on-site and prior to building "dry-in", to prevent any damage resulting from inclement weather or construction traffic. Sheet metal/specialties shall not be stored outdoors.
- C. Equipment exposed to weather during shipping and/or storage on site shall be plastic shrink-wrapped by the manufacturer to prevent damage due to weather and road debris during transportation and thereafter while in storage awaiting installation.
- D. Prevent dirt and construction debris from accumulating inside equipment (including pipe and conduit, ductwork, fittings, etc.).
- E. Equipment/materials, stored or installed, found to be damaged shall be replaced with new by the Contractor, to the satisfaction of the Owner and at no additional expense. Do not store equipment with PVC material with exposure to direct sunlight.
- F. Equipment/materials shall be handled and installed in accordance with manufacturer's instructions.

3.13 PROVISION AND INSTALLATION OF EQUIPMENT

- A. For all equipment installed external to the building whether on roofs, supports, grade, etc., the installation must comply with wind loading and impact requirements of the applicable codes for this project site.
- B. All equipment being furnished on this project, shall be certified by the manufacturer that the equipment item meets the applicable seismic, wind, earthquake, and hurricane impact requirements as set forth by the Authority Having Jurisdiction overseeing this project, and as defined in the following codes:

1. Florida Building Code – Section 1626 High Velocity Hurricane Zones impact Tests for Windborne Debris
 2. South Florida Building Code - Rev. 1994 - Section 2315 "Impact Tests"
 3. International Building Code - Section 1609 "Wind Loads"
 4. International Building Code – Section 1621 "Earthquake Loads"
- C. Equipment furnished for use in Florida shall be certified to meet the large and small missile impact test as defined in the Florida Building Code.
- D. Compliance with the above Paragraphs B and C can be reduced and/or eliminated if the equipment being provided is located inside a structural building enclosure, designed by a licensed professional Architect and Structural Engineer.
- E. Avoid interference with structure and with work of other trades, preserving adequate headroom and clearing doors and passageways, to satisfaction of Architect and in accordance with code requirements. Installation shall permit clearance for access to equipment for repair, servicing and replacement.
- F. Install equipment so as to properly distribute equipment loads on building structural members provided for equipment support under other Sections. Roof-mounted equipment shall be installed and supported on structural steel provided under other Sections.
- G. Provide suspended platforms, strap hangers, brackets, shelves, stands or legs as necessary for floor, wall or ceiling mounting of equipment as required.
- H. Provide steel supports and hardware for proper installation of hangers, anchors, guides, etc.
- I. Provide cuts, weights, and other pertinent data required for proper coordination of equipment support provisions and installation.
- J. Structural steel and hardware shall conform to Standard Specifications of ASTM; use of steel and hardware shall conform to requirements of Section Five of Code of Practice of American Institute of Steel Construction.
- K. If it is determined that in order to install equipment in an existing space, disassembling of the equipment will be required, the Architect shall be notified immediately, prior to ordering equipment. Confirmation that equipment factory warranties will not be voided shall be confirmed in writing. Arrangements for factory-authorized assembly at the job site shall then be made and be considered part of the construction cost.
- L. No piping or ductwork shall pass over electrical apparatus. Piping, ductwork or equipment installed in dedicated electrical spaces as defined in NFPA shall be relocated at no additional expense.
- M. Wherever the installation of this Contractor's equipment destroys the radiological integrity of a wall, floor, or ceiling, this Contractor shall be responsible to provide suitable lead shielding to maintain that integrity. Coordinate these requirements with the General Contractor.

- N. Route all piping and conduit concealed in walls or above ceiling (exceptions: Mechanical/Electrical Rooms), unless noted otherwise.
- O. Contractor shall label all reheat coil access doors with actual reheat coil number with indelible marker.

3.14 IDENTIFICATION

- A. After painting and/or covering is completed, identify all equipment and piping as hereinafter indicated. Locate identification as conspicuously as possible except where such would distract from the finished area.

ENG. NOTE: *Edit the following list - project specific. Coordinate labeling with Owner.*

PIPING

- 1. Cold Water
- 2. Hot Water (Domestic)
- 3. Hot Water Return (Domestic)
- 4. Heating Water Supply (HWS)
- 5. Heating Water Return (HWR)
- 6. Gas
- 7. Fuel Oil Supply (FOS)
- 8. Fuel Oil Return (FOR)
- 9. Storm
- 10. Grease Water
- 11. Non Potable Water
- 12. Fire Protection

VALVES

- CW-1, CW-2, CW-3, etc.
- HW-1, HW-2, HW-3, etc.
- HR-1, HR-2, HR-3, etc.
- HWS-1, HWS-2, HWS-3, etc.
- HWS-1, HWS-2, HWS-3, etc.
- GAS-1, GAS-2, GAS-3, etc.
- FOS-1, FOS-2, FOS-3, etc.
- FOR-1, FOR-2, FOR-3, etc.
- N/A
- N/A
- NPW-1, NPW-2, NPW-3, etc.
- FP-1, FP-2, FP-3, etc.

- B. Identify all major equipment, including air handling units, rooftop units, pumps, fans, boilers, chillers, heat exchangers, water heaters, water softeners, fire and jockey pumps, booster pumps, recirculating pumps, tanks, etc.
- C. Identify equipment by stenciling equipment number and service in 2 inch high letters with 1 coat of black enamel paint.
- D. Identify piping not less than once every 20 feet or inches, not less than once in each room, at each branch, adjacent to each access door or panel, at each valve and where exposed piping passes through walls and floors.
- E. Place flow directional arrows at each pipe identification location.
- F. Identify piping by stenciling with 1 coat of black enamel paint. Height of lettering to be same as pipe diameter, up to a maximum of 1 inch in height. When finished color of piping is dark, stenciling to be on white background.
- G. Valve number shall be prefixed with the corresponding piping system identification letters.
- H. Furnish a typewritten chart indicating equipment and areas supplied by each number valve and incorporate into Instructional Manual.

- I. Furnish a typewritten chart together with color code identification and location of all access panels serving equipment and valves. This includes the location of color-coded identification screws located in accessible ceilings. Incorporate chart into Instruction Manual.
- J. Furnish a typewritten chart including valve numbers, specific service and location for all valves (valve numbers shall coincide with brass valve tags). Incorporate chart into Operations and Maintenance Manual.
- K. Identify control equipment with laminated plastic nameplates 1/8 inch thick by approximately 1-1/2 inches X 4 inches with 1/2 inch high lettering. Face of plastic shall be black with white letters.
- L. Motor nameplates shall be located for easy reading. Relocate or provide new nameplates on motors if they are not located for easy reading.
- M. Label all fire damper access doors "FD" and all fire/smoke dampers "FSD".

3.15 LUBRICATION

- A. Upon completion of the work and before turning over to the Owner, clean and lubricate all bearings except sealed and permanently lubricated bearings. Use only lubricant recommended by the manufacturer.
- B. Contractor is responsible for maintaining lubrication of all mechanical equipment under his contract until work is accepted by Owner.
- C. Furnish a typewritten chart with each piece of equipment listed, itemizing locations for lubrication and recommended periods for lubrication. Incorporate chart in Lubrication Manual and Instruction Manual.
- D. Furnish to the Architect for approval, three typewritten lubrication manuals in loose leaf binders. One approved copy shall be returned to the Contractor for his use during the Owner instruction period. At the end of this period it shall be returned to the Architect.
- E. Lubrication manual shall consist of a separate page for each item of equipment requiring lubrication, listing locations for lubrication, lubricant required, recommended periods for lubrication, date last lubricated, and spaces for recording periodic lubrication.

3.16 PAINTING

- A. Equipment installed shall have shop coat of non-lead gray paint. Hangers and supports shall have one coat of non-lead red primer. Machinery such as pumps, fans, etc., shall be stenciled with equipment name. Stencil shall be at least 6 inches high for large equipment, 2 inches high for small equipment. Finish painting, including painting of various piping and duct systems, shall be specified under other Sections.
- B. Note requirement for Architect's approval invoked under Article 3.2 MATERIALS AND WORKMANSHIP regarding finish of material and equipment which are visible or subject to corrosive or atmospheric conditions.

- C. All exposed equipment, piping, hangers, etc., shall be painted by the Contractor. Confirm with Owner the color scheme prior to commencing with painting. Unless otherwise directed, each system shall be painted according to the following schedule:

SYSTEM	COLOR
Domestic Hot Water	Orange
Domestic Cold Water	Yellow
Sanitary Waste and Vent	Green
Hot Water Supply & Return	Green
Gas	Blue
Automatic Sprinkler	Orange
Vents/Drains	Yellow
Condenser Water	Red

Note: Paint manufacturer numbers may differ. A direct match is not required.

- D. Furnish all equipment with factory applied prime finish, unless otherwise specified.
- E. If the factory finish on any equipment furnished by the Contractor is damaged in shipment or during construction of the building, the equipment shall be refinished by the Contractor to the satisfaction of the Architect.
- F. Furnish one can of aerosol-free touch-up paint for each different color factory finish which is to be the final finished surface of the product.

3.17 EXPANSION PROVISIONS

- A. Installation of piping must allow for expansion using offsets, loops, swing joints, expansion joints, etc., as necessary to prevent undue strain. Take-offs from mains to run-outs shall not have less than a three-elbow swings.
- B. Mains and risers with loops or offsets shall be securely anchored to structure so as to impart expansion toward loops or offsets. Anchors shall be constructed of heavy forged wrought iron, secured to pipe and to structure. Provide vibration isolation as required.
- C. Provide pipe alignment guides as required to guide expanding pipe to move freely from anchor points toward expansion joints, offsets, etc.

3.18 CLEANING

- A. Cleaning shall be performed prior to system start-up.
- B. Ductwork
1. Ducts shall be thoroughly cleaned so that no dirt or dust will be discharged from diffusers, registers or grilles, when system is operated.
 2. Clean all ductwork both internally and externally to remove all dirt, plaster dust or other foreign materials. When external surfaces of ductwork are rusted, clean and restore surfaces to original condition.

3. Provide temporary connections required for cleaning. Provide cheesecloth for openings during cleaning.
 4. Replace filters prior to final inspection and testing.
- C. Piping
1. General:
 - a. After all piping systems have been pressure tested and approved for tightness, flush and clean piping as specified and as required by codes.
 - b. Furnish pipe cleaning chemicals, chemical feed equipment, materials and labor necessary to flush and clean piping.
 - c. Permanently install necessary chemical injection fittings complete with stop valves.
 - d. Monitor the water temperatures and prevent the heat generated by the pump circulating the water from causing the water temperature to exceed the temperature ratings of the pipe, pumps, and other components of the piping system during the flushing and cleaning process.
 - e. Contractor to provide a portable temporary pumping apparatus for the purpose of flushing and cleaning. Pump shall be adequate to provide the required velocities necessary for the process.
 - f. When external surfaces of piping are rusted, clean and restore surfaces to original condition.
 2. Flushing:
 - a. All water side equipment control valves, strainers, etc., shall be bypassed prior to and during the flushing process.
 - b. Flush all water, steam and condensate systems clear of all dirt and foreign matter with all pumps bypassed. All flushing to be at a circulation rate of 6 f.p.s.
 - c. Maintain continuous blowdown and make-up, as required during flushing operation.
 - d. Once flushing is complete and prior to cleaning, all final connections to equipment shall be performed.
 - e. Water samples taken from the system during flushing shall determine when the system is ready for the cleaning process.
 3. Cleaning:

- a. Clean all pipeline strainer baskets and return to original condition or replace with new baskets prior to the pipe cleaning process.
- b. The cleaning chemicals shall be designed to remove deposition from construction, such as pipe dope, oils, loose mill scale, and other extraneous silt and mud. The products shall inhibit corrosion of the various metals in the system and shall be safe to handle and use with normal chemical safety equipment, i.e., gloves and safety glasses. Effectiveness of the product shall be such that the water need only be at ambient temperatures.
- c. During the cleaning procedure, remove strainers, automatic air vents, flow regulators and any other item that would be affected by the clean and flush procedure. All control valves and coils should be set up for wide open, full flow.
- d. After initial flushing of a system, use portable pumping apparatus for a continuous 24 hour circulation of a cold water detergent equal to Nalco 2567 cleaner.
- e. After circulating for the prescribed time, systems shall then be drained and flushed until the total alkalinity or conductivity of the rinse water is not more than 20% higher than the readings for the make-up water. Refill with clean water, and treat with scale and corrosion inhibitor. Contractor shall furnish the chemicals, supervise the cleaning, test the water after flushing, and shall provide a report that certifies successful cleaning and flushing of the piping.

D. Equipment

1. After completion of project, clean the exterior surface of all equipment, including concrete residue, dirt, paint residue, etc.
2. Clean all equipment and plumbing fixtures, as recommended by manufacturer.
3. Thoroughly disinfect all water heating equipment and the complete new domestic water piping system according to Department of Health requirements.
4. All dirt, plaster dust and other foreign matter shall be blown and/or cleaned from coils, terminal devices, diffusers, registers, and grilles.
5. Thoroughly clean equipment of all stains, paint spots, dirt, and dust. Remove all temporary labels not used for instruction or operation.

3.19 DEMOLITION

- A. Refer to all drawings for general description of areas requiring demolition.
- B. Refer to General Contractor's/Construction Manager's Instructions for all existing equipment and materials that shall remain the property of the Owner.

- C. Items of value which are not directed to be returned to the Owner, shall become the property of the Contractor. Storage or sale of items on the project site is prohibited.
- D. Protection: Ensure the safe passage of persons in and around the building during demolition. Prevent injury to persons and damage to property. Provide adequate shoring and bracing to prevent collapse. Immediately repair damaged property to the condition before being damaged. Take effective measures to prevent windblown dust.
- E. Utilities: Maintain all utilities except those requiring removal or relocation. Keep utilities in service and protect from damage. Do not interrupt utilities serving used areas without first obtaining permission from the utility company and the Owner. Provide temporary services as required.
- F. Except as noted otherwise, remove from the premises, all materials and equipment removed in the demolition work.

3.20 PROJECT CLOSE-OUT PROCEDURE

- A. General
 - 1. The requirements of Divisions 15 and 16 are in addition to and supplement the requirements outlined in the General Conditions and Division 1.
 - 2. It shall be each Contractor's responsibility to personally hand-deliver all of the required project close-out checklist items and to obtain Owner's authorized representative(s) signed receipt on all items requiring Owner sign-off.
- B. Record Drawings (As-Built):
 - 1. Refer to Article 1.14 in this section for specific requirements regarding Record Drawings.
- C. Project Close-Out Checklist
 - 1. Review requirements of each section of the specifications and submit for approval to Architect the sign-off forms which shall become the project close-out checklist. These, at a minimum, shall include the following information shown in attached Project Closeout Checklist Example. The Architect and/or Owner may incorporate additional specific items to the following checklist which shall become part of the project requirements.
 - 2. Close-Out Checklist Example.

END OF SECTION 230000

SECTION 230500 - 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.

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. Mechanical demolition.
 - 9. Equipment installation requirements common to equipment sections.
 - 10. Painting and finishing.
 - 11. Concrete bases.
 - 12. Supports and anchorages.

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. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. 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."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 22 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 22 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, BAg1, 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. ABS Piping: ASTM D 2235.
 - 2. CPVC Piping: ASTM F 493.
 - 3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - 4. PVC to ABS Piping Transition: ASTM D 3138.
- I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

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: CPVC and PVC 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, CPVC PVC CPVC and PVC 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: Carbon steel. 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 waterstop, unless otherwise indicated.
- D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with set screws.
- E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
- F. PVC Pipe: ASTM D 1785, Schedule 40.
- G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

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.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated.
- D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated.
- E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
- F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.
- G. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 MECHANICAL DEMOLITION

- A. Refer to Division 1 Sections "Cutting and Patching" and "Selective Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove mechanical systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - 3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.

4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
 5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 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:
 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type with spring clips.

- d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast-brass type with polished chrome-plated finish.
 - g. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - h. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
 - i. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
2. Existing Piping: Use the following:
- a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
 - b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge and spring clips.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
 - e. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed exposed-rivet concealed or exposed-rivet hinge and set screw or spring clips.
 - g. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
 - h. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
- M. Sleeves are not required for core-drilled holes.
- N. Permanent sleeves are not required for holes formed by removable PE sleeves.
- O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
- P. 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.
- Q. 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.
- R. 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.
- S. 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.
- T. Verify final equipment locations for roughing-in.
- U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. 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.
- L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.
- M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.4 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.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install 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.

3.6 PAINTING

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

3.7 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 minimum 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 3.

3.8 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.

3.9 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.

3.10 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 230500

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following meters and gages for mechanical systems:
 - 1. Thermometers.
 - 2. Gages.
 - 3. Test plugs.
 - 4. Thermal-energy meters.
- B. Related Sections include the following:
 - 1. Division 2 Section "Water Distribution" for domestic and fire-protection water service meters outside the building.
 - 2. Division 13 Section "Electric-Drive, Centrifugal Fire Pumps for fire-pump flowmeter systems.
 - 3. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.

1.3 DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated; include performance curves.
- B. Shop Drawings: Schedule indicating manufacturer's number, scale range, and location for each.
- C. Product Certificates: For each type of thermometer, gage and flowmeter, signed by product manufacturer.
- D. Operation and Maintenance Data: For flowmeters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

- A. Manufacturers:
 - 1. Palmer - Wahl Instruments Inc.
 - 2. Terice, H. O. Co.
 - 3. Weiss Instruments, Inc.
 - 4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Case: Die-cast aluminum or brass, 9 inches long.
- C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.
- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass.
- F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
- H. 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 PLASTIC-CASE, LIQUID-IN-GLASS THERMOMETERS

- A. Manufacturers:
 - 1. Ernst Gage Co.
 - 2. Eugene Ernst Products Co.
 - 3. Marsh Bellofram.
 - 4. Miljoco Corp.
 - 5. Terice, H. O. Co.

6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
 7. Winters Instruments.
- B. Case: Plastic, 9 inches long.
 - C. Tube: Red or blue reading, mercury or organic-liquid filled, with magnifying lens.
 - D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 - E. Window: Glass or plastic.
 - F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
 - G. Stem: Metal, for thermowell installation and of length to suit installation.
 - H. 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 DUCT-TYPE, LIQUID-IN-GLASS THERMOMETERS

- A. Manufacturers:
 1. Miljoco Corp.
 2. Palmer - Wahl Instruments Inc.
 3. Trerice, H. O. Co.
 4. Weiss Instruments, Inc.
- B. Case: Metal or plastic, 7 inches long.
- C. Tube: Red or blue reading, mercury or organic filled, with magnifying lens.
- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass or plastic.
- F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- G. Stem: Metal, for installation in mounting bracket and of length to suit installation.
- H. Mounting Bracket: Flanged fitting for attachment to duct and made to hold thermometer stem.
- I. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.5 THERMOWELLS

- A. Manufacturers:

1. AMETEK, Inc.; U.S. Gauge Div.
2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
3. Palmer - Wahl Instruments Inc.
4. Tel-Tru Manufacturing Company.
5. Trerice, H. O. Co.
6. Weiss Instruments, Inc.
7. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Manufacturers: Same as manufacturer of thermometer being used.

C. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.6 PRESSURE GAGES

A. Manufacturers:

1. AMETEK, Inc.; U.S. Gauge Div.
2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
3. Palmer - Wahl Instruments Inc.
4. Trerice, H. O. Co.
5. Weiss Instruments, Inc.
6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case: Liquid-filled type, drawn steel or cast aluminum 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 metal.
7. Window: Glass.
8. Ring: Metal
9. Accuracy: Grade B, plus or minus 2 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

C. Remote-Mounting, Dial-Type Pressure Gages: ASME B40.100, indicating-dial type.

1. Case: Dry type, drawn steel or cast aluminum, 6-inch diameter with holes for panel mounting.
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 metal.
7. Window: Glass.

8. Ring: Metal.
9. Accuracy: Grade B, plus or minus 2 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure
11. Range for Fluids under Pressure: Two times operating pressure.

D. Pressure-Gage Fittings:

1. Valves: NPS 1/4 brass or stainless-steel needle type.
2. Syphons: 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.

2.7 TEST PLUGS

A. Manufacturers:

1. Flow Design, Inc.
2. MG Piping Products Co.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.
7. Watts Industries, Inc.; Water Products Div.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

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

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.

E. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, two thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.

1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be 0 to 200 psig.
2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F.
3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
4. Carrying case shall have formed instrument padding.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

- A. Install liquid-in-glass thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler and chiller.
 - 3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
 - 4. Inlet and outlet of each hydronic heat exchanger.
 - 5. Inlet and outlet of each hydronic heat-recovery unit.
 - 6. Inlet and outlet of each thermal storage tank.
 - 7. Outside-air, return-air, and mixed-air ducts.
- B. Install direct-mounting, vapor-actuated dial thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
 - 2. Inlet and outlet of each hydronic heat exchanger.
 - 3. Inlet and outlet of each hydronic heat-recovery unit.
 - 4. Inlet and outlet of each thermal storage tank.
- C. Install remote-mounting, vapor-actuated dial thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler and chiller.
 - 3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
 - 4. Inlet and outlet of each hydronic heat exchanger.
 - 5. Inlet and outlet of each hydronic heat-recovery unit.
 - 6. Inlet and outlet of each thermal storage tank.
- D. Install bimetallic-actuated dial thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler and chiller.
 - 3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
 - 4. Inlet and outlet of each hydronic heat exchanger.
 - 5. Inlet and outlet of each hydronic heat-recovery unit.
 - 6. Inlet and outlet of each thermal storage tank.
- E. Install liquid-filled-case-type, vapor-actuated dial thermometers at suction and discharge of each pump.
- F. Provide the following temperature ranges for thermometers:
 - 1. Domestic Hot Water: 30 to 240 deg F, with 2-degree scale divisions.
 - 2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.
 - 3. Air Ducts: Minus 40 to plus 110 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

- A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.
- B. Install liquid-filled-case-type pressure gages at chilled- and condenser-water inlets and outlets of chillers.
- C. 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 remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.
- C. Install thermowells with socket extending one-third of diameter of pipe and in vertical position in piping tees where thermometers are indicated.
- D. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.
- E. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
- F. Install remote-mounting pressure gages on panel.
- G. Install needle-valve and snubber fitting in piping for each pressure gage for fluids.
- H. Install needle-valve and syphon fitting in piping for each pressure gage for steam.
- I. Install test plugs in tees in piping.
- J. Install flow indicators, in accessible positions for easy viewing, in piping systems.
- K. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters as prescribed by manufacturer's written instructions.
- L. Install flowmeter elements in accessible positions in piping systems.
- M. Install differential-pressure-type flowmeter elements with at least minimum straight lengths of pipe upstream and downstream from element as prescribed by manufacturer's written instructions.
- N. Install wafer-orifice flowmeter elements between pipe flanges.
- O. Install permanent indicators on walls or brackets in accessible and readable positions.
- P. Install connection fittings for attachment to portable indicators in accessible locations.

- Q. Install flowmeters at discharge of hydronic system pumps and at inlet of hydronic air coils.
- R. Assemble components and install thermal-energy meters.
- S. Mount meters on wall if accessible; if not, provide brackets to support meters.

3.4 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.
- B. Connect flowmeter-system elements to meters.
- C. Connect flowmeter transmitters to meters.
- D. Connect thermal-energy-meter transmitters to meters.
- E. Ground equipment according to Division 26 Section "Grounding and Bonding."
- F. Connect wiring according to Division 26 Section "Conductors and Cables."

3.5 ADJUSTING

- A. Calibrate meters according to manufacturer's written instructions, after installation.
- B. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION 230519

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following hangers and supports for mechanical system piping and equipment:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Fastener systems.
 - 5. Equipment supports.
- B. Related Sections include the following:
 - 1. Division 5 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 13 Section "Fire-Suppression Piping" for pipe hangers for fire-protection piping.
 - 3. Division 22 Section "Pipe Expansion Fittings and Loops" for pipe guides and anchors.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel pipe hangers and supports.
 - 2. Thermal-hanger shield inserts.
 - 3. Powder-actuated fastener systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze pipe hangers. Include Product Data for components.
 - 2. Metal framing systems. Include Product Data for components.
 - 3. Pipe stands. Include Product Data for components.
 - 4. Equipment supports.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."
- B. Welding: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1, "Structural Welding Code--Steel."
 - 2. AWS D1.4, "Structural Welding Code--Reinforcing Steel."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 STEEL PIPE HANGERS AND SUPPORTS

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
- B. Manufacturers:
 - 1. B-Line Systems, Inc.; a division of Cooper Industries.
 - 2. Globe Pipe Hanger Products, Inc.

3. Grinnell Corp.
4. National Pipe Hanger Corporation.
5. PHD Manufacturing, Inc.

- C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

- A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.
- B. Manufacturers:
1. B-Line Systems, Inc.; a division of Cooper Industries.
 2. Power-Strut Div.; Tyco International, Ltd.
 3. Thomas & Betts Corporation.
 4. Unistrut Corp.; Tyco International, Ltd.
- C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

- A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Manufacturers:
1. PHS Industries, Inc.
 2. Pipe Shields, Inc.
 3. Value Engineered Products, Inc.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

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

2.6 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Manufacturers:
 - a. Hilti, Inc.
 - b. ITW Ramset/Red Head.
 - c. Masterset Fastening Systems, Inc.
 - d. Powers Fasteners.
- B. Mechanical-Expansion Anchors: Insert-wedge-type stainless steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Manufacturers:
 - a. B-Line Systems, Inc.; a division of Cooper Industries.
 - b. Hilti, Inc.
 - c. ITW Ramset/Red Head.
 - d. Powers Fasteners.

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

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

- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 - 2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 6, if little or no insulation is required.
 - 3. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 4. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
 - 5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 - 6. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
 - 7. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
 - 8. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 6.
 - 9. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 10. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 8, from single rod if horizontal movement caused by expansion and contraction might occur.
 - 11. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 8, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 - 12. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 8, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 - 13. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 8, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- F. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 8.
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 8, if longer ends are required for riser clamps.
- G. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 - 2. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
- H. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- I. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
- J. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.

3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to 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.
- K. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- L. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- M. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- N. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.
- 3.2 HANGER AND SUPPORT INSTALLATION
- A. Steel Pipe Hanger 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. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified 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 D1.1.
- C. Fastener System Installation:
1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that

- are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- D. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- E. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- F. 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.
- G. Install lateral bracing with pipe hangers and supports to prevent swaying.
- H. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- I. Load Distribution: Install hangers and supports so 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 (for building services piping) are 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 B31.1 for power piping and ASME B31.9 for building services piping.
 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 5. Insert Material: Length at least as long as protective shield.
 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 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 Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 painting Sections.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 23 05 29

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to 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. Pipe markers.
- 5. Stencils.
- 6. Valve tags.
- 7. Valve schedules.
- 8. 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 EQUIPMENT IDENTIFICATION DEVICES

- A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
 - 1. Data:
 - a. Manufacturer, product name, model number, and serial number.
 - b. Capacity, operating and power characteristics, and essential data.
 - c. Labels of tested compliances.
 - 2. Location: Accessible and visible.
 - 3. Fasteners: As required to mount on equipment.
- B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.
 - 1. Terminology: Match schedules as closely as possible.
 - 2. Data:
 - a. Name and plan number.
 - b. Equipment service.
 - c. Design capacity.
 - d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.
 - 3. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.
- C. 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, unless otherwise indicated.
 - 4. Thickness: 1/16 inch for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.
 - 5. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.
- D. Access Panel and Door Markers: 1/16-inch-thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.
 - 1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

- A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
 - 1. Colors: Comply with ASME A13.1, unless otherwise indicated.
 - 2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
 - 3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
 - 4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type 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. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.
- C. Shaped Pipe Markers: Preformed semirigid 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 thick with pressure-sensitive, permanent-type, self-adhesive back.
 - 1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
 - 2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

2.3 STENCILS

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

2.4 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by Architect <Insert other>. Provide 5/32-inch hole for fastener.
 - 1. Material: 0.032-inch- thick aluminum.
 - 2. Material: 0.0375-inch- thick stainless steel.
 - 3. Material: 3/32-inch- thick laminated plastic with 2 black surfaces and white inner layer.

4. Valve-Tag Fasteners: Brass wire-link or beaded chain; or S-hook VALVE SCHEDULES
 - B. 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.
- 2.5 WARNING TAGS
- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.
 1. Size: Approximately 4 by 7 inches Fasteners: Brass grommet and wire.
 2. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
 3. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

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

3.2 PREPARATION

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

3.3 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. Pumps, compressors, chillers, condensers, and similar motor-driven units.
 2. Heat exchangers, coils, evaporators, and similar equipment.

- B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.
 - 1. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches 1/2 inch for viewing distances up to 72 inches , and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
 - 3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
 - a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
 - b. Fire department hose valves and hose stations.
 - c. Meters, gages, thermometers, and similar units.
 - d. Pumps, compressors, condensers, and similar motor-driven units.
- 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 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. Orange: For combination cooling and heating equipment and components.
 - 2. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches , and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 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. Pumps, compressors, condensers, and similar motor-driven units.
- 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 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.

3.4 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: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 3/4 inch 1-1/2 inches wide, lapped at least 1-1/2 inches at both ends of pipe marker, and covering full circumference of pipe.
 - 2. Pipes with OD, Including Insulation, 6 Inches and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 3 inches at both ends of pipe marker, and covering full circumference of pipe.
- B. Stenciled Pipe Marker Option: Stenciled markers may be provided instead of manufactured pipe markers, at Installer's option. Install stenciled pipe markers 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 nonconcealed 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 nonaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.
- D. Pipe Label Color Schedule:
 - 1. Heating Water Piping: White letters on a safety-green background
 - 2. Refrigerant Piping: Black letters on a safety-white background

3.5 DUCT LABEL INSTALLATION

- A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
 - 1. Blue For cold-air supply ducts.
 - 2. Yellow For hot-air supply ducts.
 - 3. Green For exhaust-, outside-, relief-, return-, and mixed-air ducts.
 - 4. ASME A13.1 Colors and Designs: For hazardous material exhaust.
- B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch

(25 mm) high is needed for proper identification because of distance from normal location of required identification.

- C. Locate labels 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.

3.6 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:

- 1. Valve-Tag Size and Shape:

- a. Cold Water: 1-1/2 inches, 2 inches, round square.
- b. Hot Water: 1-1/2 inches, 2 inches, round square.
- c. Refrigerant: 1-1/2 inches square
- d. Fire Protection: 1-1/2 inches, 2 inches, round square.
- e. Gas: 1-1/2 inches, 2 inches, round square.

- 2. Valve-Tag Color:

- a. Cold Water: Green .
- b. Fire Protection: Red
- c. Gas: Yellow

- 3. Letter Color:

- a. Cold Water: White.
- b. Fire Protection: White.
- c. Gas: White.

3.7 VALVE-SCHEDULE INSTALLATION

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

3.8 WARNING-TAG INSTALLATION

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

3.9 ADJUSTING

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

3.10 CLEANING

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

END SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Balancing Air Systems:
 - a. Constant-volume air systems.

1.2 DESCRIPTION

- A. This Contractor shall be responsible for providing a complete test-adjust-balance (TAB) work of all systems including systems and the equipment and apparatus connected.
- B. The schedule for testing and balancing shall be established by the Contractor in coordination with the TAB agency to complete the work prior to project substantial completion. Work is not considered complete until approved, in writing, by signing Engineer or Architect.
- C. The items requiring testing, adjusting, and balancing include but are not limited to the following:
 - 1. AIR SYSTEMS:
 - a. Air handling and fan coil units
 - b. Ductwork systems
 - c. Fans
 - d. Diffusers, Registers and Grilles
 - e. Coils (Air Temperatures)
 - f. Project Differential Pressure Requirements
 - g. Project Temperature Requirements
 - h. Smoke Detectors (If Provided)
 - i. Control dampers
 - 2. HYDRONIC SYSTEMS:
 - a. Pumps
 - b. Hydronic piping systems
 - c. Heat Exchangers
 - d. Coils
 - 3. Plumbing Systems
 - a. Pressure booster pumps
 - b. Hot water recirculation pumps and branch balancing valves
 - c. Filtration systems
 - d. Any other circulation systems
- D. Test and Balance Contractor shall submit to the engineer a T&B Work Plan prior to the commencement of work. The work plan shall be project specific.

- E. The accuracy of measurements shall be in accordance with AABC National Standards or NEBB Procedural Standards for TAB Environmental Systems. Adjustment tolerances shall be + or - 5% unless otherwise stated.
- F. Air systems shall be balanced to maintain the positive and negative space pressure relationships indicated in the Contract Documents.
- G. The TAB Contractor is required to be at the final AHCA inspection or Owner's substantial completion and be prepared to test 10% of the air distribution devices and water distribution devices to prove that his final report and the design professional's review were correct.
- H. Upon direction of the Architect, Engineer or the TAB Contractor, the installing Contractor shall provide, at no additional cost to the Owner, any additional work and/or devices necessary to properly balance the system, including fan sheaves, motor sheave, drive belts, balancing damper, calibrated balancing valves, gauge tapings, flow sensors, and thermometer wells. He shall also be responsible for trimming and balancing constant speed pump impellers as determined by TAB to maximize pump efficiency.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 SUBMITTALS

- A. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 15days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- D. Certified TAB reports.
- E. Sample report forms.
- F. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.

3. Application.
4. Dates of use.
5. Dates of calibration.

G. REPORTS

1. Submit six certified bound copies of the final reports on applicable AABC or NEBB Reporting Forms for review and approval by the Engineer. Provide one copy at the site prior to request for final inspection.
2. All outlets, devices, HVAC equipment, etc., shall be identified, along with a numbering system corresponding to report unit identification.
3. A completed and approved certified copy of the test and balance report shall be available at the project site at the 100% AHCA inspection.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC NEBB or TABB.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC NEBB or TABB as a TAB technician.

B. TAB Conference: Meet with Construction Manager on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Coordination and cooperation of trades and subcontractors.
 - d. Coordination of documentation and communication flow.

C. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB contractor's forms approved by Owner and Engineer.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

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

1.7 COORDINATION

- A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.
- C. Any deficiencies in the installation or performance of a system or component observed by the TAB agency shall be brought to the attention of the appropriate responsible Contractor or person.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
- B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- J. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- K. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- M. Examine system pumps to ensure absence of entrained air in the suction piping.
- N. Examine operating safety interlocks and controls on HVAC equipment.
- O. 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 COORDINATION AND SCHEDULING

- A. The schedule for testing and balancing shall be established by the Contractor in coordination with the balancing agency to complete the work prior to project substantial completion.
- B. It will be necessary for the balancing agency to perform its services in close coordination with the Contractor and Mechanical Subcontractor.
- C. The Contractor shall furnish to the TAB agency a complete set of plans, specifications, approved HVAC submittal data and shop drawings, up-to-date revisions, and other data required for planning, preparation, and execution of the TAB work. This information shall be provided to the TAB agency no later than 30 days prior to the start of TAB work.
- D. The installing Contractor shall provide a minimum of three weeks written notification to the Architect/Engineer and TAB Contractor that system installations are complete and are ready for testing.
- E. System installation and equipment startup shall be complete prior to the TAB agency being notified by the Contractor to begin the TAB.
- F. The Contractor, subcontractors and equipment suppliers shall all cooperate with the TAB agency to provide all necessary data on the design and proper application of the system components. In addition, they shall furnish all labor and materials required to eliminate reported system deficiencies in a timely manner.

- G. The building control system shall be complete and operational. The Controls Contractor shall install all necessary computers and computer programs, and make these operational. Assistance shall be provided as required for reprogramming, coordination, and problem resolution.
- H. All test points, balancing devices, identification tags, etc. shall be accessible and clear of insulation and other obstructions that would impede TAB procedures.
- I. Qualified installation or startup personnel shall be readily available for the operation and adjustment of the systems. Assistance shall be provided as required for coordination and problem resolution.
- J. Corrections of minor deficiencies identified may be made during the tests at the discretion of the TAB Contractor. In such cases the deficiency and resolution will be documented in the final report.
- K. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures.

3.3 DEFICIENCY RESOLUTION

- A. As test progresses and a deficiency is identified, the TAB Contractor shall coordinate with the Contractors to identify the deficiency for a timely resolution of the deficiency.
- B. This Contractor shall include in their base bid the initial test and balance, plus returning to the site for two (2) additional visits to retest systems that do not test within specification requirements. Any additional testing requirements will fall under requirements listed under Cost of Retesting.
- C. Cost of Retesting
 - 1. The cost for any additional testing beyond requirement in Paragraph B shall be borne by the installing Contractors, if they are responsible for the deficiency. If they are not responsible, any cost for retesting shall be negotiated with the Contractor.
 - 2. The time for the Architect/Engineer to direct any retesting required because a specific system reported to have been successfully completed, but determined during testing to be faulty, will be back-charged to the Contractor, who may choose to recover costs from the party responsible for stating system was complete.
- D. Failure Due to Manufacturer Defect. If 10%, or three, whichever is greater, of identical pieces (size alone does not constitute a difference) of equipment fail to perform to the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance, then all identical units may be considered unacceptable by the TAB agent or the Engineer. In such case, the Contractor shall provide the Owner with the following:

1. Within one week of notification from the TAB agent, the Contractor or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the Architect/Engineer within two weeks of the original notice.
2. Within two weeks of the original notification, the Contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.
3. The Architect/Engineer will determine whether a replacement of all identical units or a repair is acceptable.
4. Two examples of the proposed solution will be installed by the Contractor then test the installations for up to one week, upon which the Architect/Engineer will decide whether to accept the solution.
5. Upon acceptance, the Contractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.

3.4 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system-readiness checks and prepare 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, smoke, and fire 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.

3.5 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.
 1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."
 3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.6 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. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

3.7 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.

- b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 2. Measure fan static pressures as follows to determine actual static pressure:
 - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - a. Report the cleanliness status of filters and the time static pressures are measured.
 4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
 5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 6. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 15 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
 1. Measure airflow of submain and branch ducts.
 - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
 3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

- C. Measure air outlets and inlets without making adjustments.
 - 1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. General Building/Zone Pressurization:
 - 1. The TAB agency shall test and adjust building/zone pressurization by setting the design flows to meet the required flow direction and pressure differential. For positive pressure areas, set the supply air to design flow, and gradually reduce as required the return/exhaust air rate to obtain the required flow or pressure difference. For negative pressure areas, set the supply air to design flow, and gradually increase as required the return/exhaust air rate to obtain the required flow or pressure difference.
 - 2. Provide in the TAB report building/zone pressurization indicating the differential pressures of required positive areas, negative areas, and project common spaces to the exterior.
- E. Pressure Sensitive Spaces
 - 1. Coordinate TAB activities with BAS Contractor for pressure-sensitive spaces such as isolation rooms, laboratory spaces, clean rooms, operating rooms, procedure rooms, etc.
 - 2. Pressure sensitive rooms with relative pressure monitors should be balanced so they are 0.05" positive or negative to adjacent spaces. Assist contractors with setting up and alarming the wall mounted pressure monitor. The low level alarm should be set at 0.01".
 - 3. Laboratory spaces to be balanced based upon relative pressures between adjacent spaces. Adjust airflows up or down (from design values) to meet relative pressure requirements.
 - 4. If relative pressures cannot be achieved, then inspect wall and ceiling sealing for visible cracks and air leaks. Advise General Contractor to seal noticeable cracks. If pressures cannot be achieved after wall/ceiling remediation, then advise engineer of the intended actions to increase supply/exhaust airflows as necessary to achieve target relative space pressures.
 - 5. For systems with Phoenix air valves, adjust airflows on air valves as necessary to achieve a minimum of 0.01" relative pressure from room to room.
- F. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
 - 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 - 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

- G. Verify final system conditions.
 - 1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
 - 2. Re-measure and confirm that total airflow is within design.
 - 3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
 - 4. Mark all final settings.
 - 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
 - 6. Measure and record all operating data.
 - 7. Record final fan-performance data.

3.8 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 - 1. Manufacturer's name, model number, and serial number.
 - 2. Motor horsepower rating.
 - 3. Motor rpm.
 - 4. 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 of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.9 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each water coil:
 - 1. Entering- and leaving-water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.
 - 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. Measure, adjust, and record the following data for each electric heating coil:
 - 1. Nameplate data.
 - 2. Airflow.
 - 3. Entering- and leaving-air temperature at full load.
 - 4. Voltage and amperage input of each phase at full load and at each incremental stage.
 - 5. Calculated kilowatt at full load.
 - 6. Fuse or circuit-breaker rating for overload protection.

3.10 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

- A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
 - 1. Measure and record the operating speed, airflow, and static pressure of each fan.
 - 2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
 - 3. Check the refrigerant charge.
 - 4. Check the condition of filters.
 - 5. Check the condition of coils.
 - 6. Check the operation of the drain pan and condensate-drain trap.
 - 7. Check bearings and other lubricated parts for proper lubrication.
 - 8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
- B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
 - 1. New filters are installed.
 - 2. Coils are clean and fins combed.
 - 3. Drain pans are clean.
 - 4. Fans are clean.
 - 5. Bearings and other parts are properly lubricated.
 - 6. Deficiencies noted in the preconstruction report are corrected.
- C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
 - 1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
 - 2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
 - 3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
 - 4. Balance each air outlet.

3.11 DUCT LEAKAGE TESTS

- A. Witness the duct pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- C. Report deficiencies observed.

3.12 CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 - 1. Verify temperature control system is operating within the design limitations.
 - 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 - 3. Verify that controllers are calibrated and function as intended.
 - 4. Verify that controller set points are as indicated.
 - 5. Verify the operation of lockout or interlock systems.
 - 6. Verify the operation of valve and damper actuators.
 - 7. Verify that controlled devices are properly installed and connected to correct controller.
 - 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
 - 9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.
- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.13 TOLERANCES

- A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 5 percent.
 - 2. Air Outlets and Inlets: Plus or minus 5 percent.
 - 3. Heating-Water Flow Rate: Plus or minus 5 percent.
 - 4. Cooling-Water Flow Rate: Plus or minus 5 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: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.15 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.

- B. Final Report Contents: In addition to certified field-report data, include the following:
1. Pump curves.
 2. Fan curves.
 3. Manufacturers' test data.
 4. Field test reports prepared by system and equipment installers.
 5. Other information relative to equipment performance; do not include Shop Drawings and product data.
- C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
 2. Name and address of the TAB contractor.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.

7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 3. Test Data (Indicated and Actual Values):
 - a. Total air flow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Filter static-pressure differential in inches wg.
 - f. Preheat-coil static-pressure differential in inches wg.
 - g. Cooling-coil static-pressure differential in inches wg.
 - h. Heating-coil static-pressure differential in inches wg.
 - i. Outdoor airflow in cfm.
 - j. Return airflow in cfm.
 - k. Outdoor-air damper position.
 - l. Return-air damper position.
 - m. Vortex damper position.
- F. Apparatus-Coil Test Reports:
1. Coil Data:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.

- e. Fin spacing in fins per inch o.c.
 - f. Make and model number.
 - g. Face area in sq. ft. .
 - h. Tube size in NPS .
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
 - 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm .
 - b. Average face velocity in fpm.
 - c. Air pressure drop in inches wg.
 - d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
 - e. Return-air, wet- and dry-bulb temperatures in deg F.
 - f. Entering-air, wet- and dry-bulb temperatures in deg F.
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
 - h. Water flow rate in gpm .
 - i. Water pressure differential in feet of head or psig.
 - j. Entering-water temperature in deg F .
 - k. Leaving-water temperature in deg F.
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig.
 - n. Refrigerant suction temperature in deg F.
 - o. Inlet steam pressure in psig.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total air flow rate in cfm .
 - b. Entering-air temperature in deg F .
 - c. Leaving-air temperature in deg F
 - d. Air temperature differential in deg F
 - e. Entering-air static pressure in inches wg.
 - f. Leaving-air static pressure in inches wg.
 - g. Air static-pressure differential in inches wg.
 - h. Low-fire fuel input in Btu/h.
 - i. High-fire fuel input in Btu/h.
 - j. Manifold pressure in psig.
 - k. High-temperature-limit setting in deg F.
 - l. Operating set point in Btu/h .
 - m. Motor voltage at each connection.
 - n. Motor amperage for each phase.
 - o. Heating value of fuel in Btu/h.
- G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
- 1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Coil identification.

- d. Capacity in Btu/h .
 - e. Number of stages.
 - f. Connected volts, phase, and hertz.
 - g. Rated amperage.
 - h. Air flow rate in cfm.
 - i. Face area in sq. ft..
 - j. Minimum face velocity in fpm.
 - 2. Test Data (Indicated and Actual Values):
 - a. Heat output in Btu/h.
 - b. Air flow rate in cfm .
 - c. Air velocity in fpm.
 - d. Entering-air temperature in deg F (deg C).
 - e. Leaving-air temperature in deg F (deg C).
 - f. Voltage at each connection.
 - g. Amperage for each phase.
- 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. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - g. Number, make, and size of belts.
 - 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, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F (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 air flow rate in cfm (L/s).
 - h. Indicated velocity in fpm (m/s).
 - i. Actual air flow rate in cfm (L/s).
 - j. Actual average velocity in fpm (m/s).
 - k. Barometric pressure in psig (Pa).

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

1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
2. Test Data (Indicated and Actual Values):
 - a. Air flow 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).

K. Instrument Calibration Reports:

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

3.18 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. Check the following for each system:
 - a. Measure airflow of at least 10 percent of air outlets.
 - b. Measure water flow of at least 10 percent of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Verify that balancing devices are marked with final balance position.
 - e. Note deviations from the Contract Documents in the final report.
- B. Final Inspection:
 1. After initial inspection is complete and documentation 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 Engineer.
 2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Construction Manager
 3. Construction Manager shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
 4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
 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.
- C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
 1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
 2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.
- D. Prepare test and inspection reports.

3.19 ADDITIONAL TESTS

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

END OF SECTION 230593

SECTION 230700 - HVAC 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.

1.2 SUMMARY

- A. This Section includes mechanical insulation for boiler breeching, duct, equipment, and pipe, including the following:

- 1. Insulation Materials:
 - a. Calcium silicate.
 - b. Cellular glass.
 - c. Flexible elastomeric.
 - d. Mineral fiber.
 - e. Phenolic foam.
 - f. Polyisocyanurate.
 - g. Polystyrene.
- 2. Fire-rated insulation systems.
- 3. Insulating cements.
- 4. Adhesives.
- 5. Mastics.
- 6. Lagging adhesives.
- 7. Sealants.
- 8. Factory-applied jackets.
- 9. Field-applied fabric-reinforcing mesh.
- 10. Field-applied cloths.
- 11. Field-applied jackets.
- 12. Tapes.
- 13. Securements.
- 14. Corner angles.

- B. Related Sections include the following:

- 1. Division 2 Section "Hydronic Distribution" for loose-fill pipe insulation in underground piping outside the building.
- 2. Division 23 Section "Metal Ducts" for duct liners.

1.3 DEFINITIONS

- A. ASJ: All-service jacket.

- B. FSK: Foil, scrim, kraft paper.
- C. FSP: Foil, scrim, polyethylene.
- D. PVDC: Polyvinylidene chloride.
- E. SSL: Self-sealing lap.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated, identify thermal conductivity, thickness, and jackets (both factory and field applied, if any).
- B. Shop Drawings: Show details for the following:
 - 1. Application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Attachment and covering of heat tracing inside insulation.
 - 3. Insulation application at pipe expansion joints for each type of insulation.
 - 4. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Removable insulation at piping specialties, equipment connections, and access panels.
 - 6. Application of field-applied jackets.
 - 7. Application at linkages of control devices.
 - 8. Field application for each equipment type.
- C. Installer Certificates: Signed by Contractor certifying that installers comply with requirements.
- D. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- E. Field quality-control inspection reports.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports."
- B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Use products manufactured by Owens-Corning, Johns Manville, Knauf, Dow Chemical, Kingspan or Certainteed except where the product of another manufacturer is specifically identified for a special type of insulation.
- B. The listing of a manufacturer as "acceptable" does not imply automatic approval. It is the sole responsibility of the Contractor to ensure that any submittals made are for products that meet or exceed the specifications included herein.

2.2 INSULATION MATERIALS

- A. Refer to Part 3 schedule articles for requirements about where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Calcium Silicate:
 - 1. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 - 2. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 - 3. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
- G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.
 - 1. Block Insulation: ASTM C 552, Type I.
 - 2. Special-Shaped Insulation: ASTM C 552, Type III.
 - 3. Board Insulation: ASTM C 552, Type IV.
 - 4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
 - 5. Preformed Pipe Insulation with Factory-Applied ASJ ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
 - 6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- H. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
- I. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.
 - 1. Products:
 - a. CertainTeed Corp.; Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Duct Wrap.
 - d. Manson Insulation Inc.; Alley Wrap.
 - e. Owens Corning; All-Service Duct Wrap.
- J. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.
 - 1. Products:
 - a. Johns Manville; HTB 23 Spin-Glas.
 - b. Owens Corning; High Temperature Flexible Batt Insulations.
- K. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide

insulation with factory-applied FSK jacket. For equipment applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.

1. Products:
 - a. CertainTeed Corp.; Commercial Board.
 - b. Fibrex Insulations Inc.; FBX.
 - c. Johns Manville; 800 Series Spin-Glas.
 - d. Knauf Insulation; Insulation Board.
 - e. Manson Insulation Inc.; AK Board.
 - f. Owens Corning; Fiberglas 700 Series.

- L. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

1. Available Products:
 - a. Fibrex Insulations Inc.; FBX.
 - b. Johns Manville; 1000 Series Spin-Glas.
 - c. Owens Corning; High Temperature Industrial Board Insulations.
 - d. Rock Wool Manufacturing Company; Delta Board.
 - e. Roxul Inc.; Roxul RW.
 - f. Thermafiber; Thermafiber Industrial Felt.

- M. Mineral-Fiber, Preformed Pipe Insulation:

1. Products:
 - a. Fibrex Insulations Inc.; Coreplus 1200.
 - b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000(Pipe Insulation.
 - d. Manson Insulation Inc.; Alley-K.
 - e. Owens Corning; Fiberglas Pipe Insulation.
2. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.
3. Type II, 1200 deg F (649 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.

- N. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

1. Products:

- a. Knauf Insulation; Permawick Pipe Insulation.
 - b. Owens Corning; VaporWick Pipe Insulation.
- O. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.
 - 1. Products:
 - a. CertainTeed Corp.; CrimpWrap.
 - b. Johns Manville; MicroFlex.
 - c. Knauf Insulation; Pipe and Tank Insulation.
 - d. Manson Insulation Inc.; AK Flex.
 - e. Owens Corning; Fiberglas Pipe and Tank Insulation.
- P. Phenolic Foam:
 - 1. Products:
 - a. Kingspan Corp.; Koolphen K.
 - 2. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
 - 3. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
 - 4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
 - 5. Factory-Applied Jacket: Requirements are specified in Part 2 "Factory-Applied Jackets" Article.
 - a. Preformed Pipe Insulation: ASJ.
 - b. Board for Duct and Plenum Applications: ASJ.
 - c. Board for Equipment Applications: ASJ.
- Q. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
 - 1. Products:
 - a. Apache Products Company; ISO-25.
 - b. Dow Chemical Company (The); Trymer.
 - c. Duna USA Inc.; Corafoam.
 - d. Elliott Company; Elfoam.
 - 2. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
 - 3. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E 84.
 - 4. Fabricate shapes according to ASTM C 450 and ASTM C 585.

- 5. Factory-Applied Jacket: Requirements are specified in Part 2 "Factory-Applied Jackets" Article.
 - a. Pipe Applications: ASJ-SSL.
 - b. Equipment Applications: ASJ-SSL.
- R. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
 - 1. Products:
 - a. Armacell LLC; Tubolit.
 - b. Nomaco Inc.; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.
 - c. RBX Corporation; Therma-cell.
- S. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K) after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.
 - 1. Products:
 - a. Dow Chemical Company (The); Styrofoam.
 - b. Knauf Insulation; Knauf Polystyrene.

2.3 FIRE-RATED INSULATION SYSTEMS

- A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F (927 deg C). Comply with ASTM C 656, Type II, Grade 6. UL tested and certified to provide a 1 or 2-hour fire rating, as required.
 - 1. Products:
 - a. Johns Manville; Super Firetemp M.
- B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is UL tested and certified to provide a 1 or 2-hour fire rating, as required.
 - 1. Products:
 - a. CertainTeed Corp.; FlameChek.
 - b. Johns Manville; Firetemp Wrap.
 - c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
 - d. Thermal Ceramics; FireMaster Duct Wrap.
 - e. 3M; Fire Barrier Wrap Products.
 - f. Unifrax Corporation; FyreWrap.
 - g. Vesuvius; PYROSCAT FP FASTR Duct Wrap.

2.4 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products:
 - a. Insulco, Division of MFS, Inc.; Triple I.
 - b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products:
 - a. P. K. Insulation Mfg. Co., Inc.; Thermal-V-Kote.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

1. Products:
 - a. Insulco, Division of MFS, Inc.; SmoothKote.
 - b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
 - c. Rock Wool Manufacturing Company; Delta One Shot.

2.5 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).

1. Products:
 - a. Childers Products, Division of ITW; CP-97.
 - b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
 - c. Marathon Industries, Inc.; 290.
 - d. Mon-Eco Industries, Inc.; 22-30.
 - e. Vimasco Corporation; 760.

C. Cellular-Glass, Phenolic-Foam, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).

1. Products:
 - a. Childers Products, Division of ITW; CP-96.
 - b. Foster Products Corporation, H. B. Fuller Company; 81-33.

D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products:
 - a. Aeroflex USA Inc.; Aeroseal.
 - b. Armacell LCC; 520 Adhesive.
 - c. Foster Products Corporation, H. B. Fuller Company; 85-75.

- d. RBX Corporation; Rubatex Contact Adhesive.
- E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Products:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.
- F. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).
 - 1. Products:
 - a. Childers Products, Division of ITW; CP-96.
 - b. Foster Products Corporation, H. B. Fuller Company; 97-13.
- G. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. Products:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.
- H. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Products:
 - a. Dow Chemical Company (The); 739, Dow Silicone.
 - b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Red Devil, Inc.; Celulon Ultra Clear.
 - e. Speedline Corporation; Speedline Vinyl Adhesive.

2.6 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Products:
 - a. Childers Products, Division of ITW; CP-35.

- b. Foster Products Corporation, H. B. Fuller Company; 30-90.
 - c. ITW TACC, Division of Illinois Tool Works; CB-50.
 - d. Marathon Industries, Inc.; 590.
 - e. Mon-Eco Industries, Inc.; 55-40.
 - f. Vimasco Corporation; 749.
 - 2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 5. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
- 1. Products:
 - a. Childers Products, Division of ITW; CP-30.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-35.
 - c. ITW TACC, Division of Illinois Tool Works; CB-25.
 - d. Marathon Industries, Inc.; 501.
 - e. Mon-Eco Industries, Inc.; 55-10.
 - 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
 - 3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 - 4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 - 5. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
- 1. Products:
 - a. Childers Products, Division of ITW; Encacel.
 - b. Foster Products Corporation, H. B. Fuller Company; 60-95/60-96.
 - c. Marathon Industries, Inc.; 570.
 - d. Mon-Eco Industries, Inc.; 55-70.
 - 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
 - 3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 - 4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - 5. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
- 1. Products:
 - a. Childers Products, Division of ITW; CP-10.
 - b. Foster Products Corporation, H. B. Fuller Company; 35-00.
 - c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
 - d. Marathon Industries, Inc.; 550.
 - e. Mon-Eco Industries, Inc.; 55-50.

- f. Vimasco Corporation; WC-1/WC-5.
- 2. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
- 3. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
- 4. Solids Content: 63 percent by volume and 73 percent by weight.
- 5. Color: White.

2.7 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
 - 1. Products:
 - a. Childers Products, Division of ITW; CP-52.
 - b. Foster Products Corporation, H. B. Fuller Company; 81-42.
 - c. Marathon Industries, Inc.; 130.
 - d. Mon-Eco Industries, Inc.; 11-30.
 - e. Vimasco Corporation; 136.
 - 2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
 - 3. Service Temperature Range: Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).
 - 4. Color: White.

2.8 SEALANTS

- A. Joint Sealants:
 - 1. Joint Sealants for Cellular-Glass, Phenolic-Foam, and Polyisocyanurate Products:
 - a. Childers Products, Division of ITW; CP-76.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-45.
 - c. Marathon Industries, Inc.; 405.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Pittsburgh Corning Corporation; Pittseal 444.
 - f. Vimasco Corporation; 750.
 - 2. Joint Sealants for Polystyrene Products:
 - a. Childers Products, Division of ITW; CP-70.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-45/30-46.
 - c. Marathon Industries, Inc.; 405.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Vimasco Corporation; 750.
 - 3. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 4. Permanently flexible, elastomeric sealant.
 - 5. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 - 6. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:

1. Products:
 - a. Childers Products, Division of ITW; CP-76-8.
 - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
 - c. Marathon Industries, Inc.; 405.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Vimasco Corporation; 750.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products:
 - a. Childers Products, Division of ITW; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.

2.9 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
6. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
 - a. Products:

- 1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
8. Vinyl Jacket: UL-rated white vinyl with a permeance of 1.3 perms (0.86 metric perms) when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.
- 2.10 FIELD-APPLIED FABRIC-REINFORCING MESH
- A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
 1. Products:
 - a. Vimasco Corporation; Elastafab 894.
 - B. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. inch (2 strands by 2 strands/sq. mm) for covering equipment.
 1. Products:
 - a. Childers Products, Division of ITW; Chil-Glas No. 5.
 - C. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave, for duct, equipment, and pipe.
 1. Products:
 - a. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.
 - b. Vimasco Corporation; Elastafab 894.
- 2.11 FIELD-APPLIED CLOTHS
- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).
 1. Products:
 - a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.
- 2.12 FIELD-APPLIED JACKETS
- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
 - B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Products:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto PVC Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: Color-code jackets based on system.
 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 5. Factory-fabricated tank heads and tank side panels.
- D. Metal Jacket:
1. Products:
 - a. Childers Products, Division of ITW; Metal Jacketing Systems.
 - b. PABCO Metals Corporation; Surefit.
 - c. RPR Products, Inc.; Insul-Mate.
 2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
 3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

- a. Sheet and roll stock ready for shop or field sizing.
 - b. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- E. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
- 1. Products:
 - a. Pittsburgh Corning Corporation; Pittwrap.
 - b. Polyguard; Insulrap No Torch 125.
- F. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.
- 1. Products:
 - a. Polyguard; Alumaguard 60.
- G. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
- 1. Products:
 - a. Dow Chemical Company (The), Saran 540 Vapor Retarder Film.
- H. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
- 1. Products:

- a. Dow Chemical Company (The), Saran 560 Vapor Retarder Film.
 - I. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
- 2.13 TAPES
- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136 and UL listed.
 1. Products:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
 - b. Compac Corp.; 104 and 105.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 2. Width: 3 inches (75 mm).
 3. Thickness: 11.5 mils (0.29 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
 - B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136 and UL listed.
 1. Products:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - b. Compac Corp.; 110 and 111.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
 - d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
 2. Width: 3 inches (75 mm).
 3. Thickness: 6.5 mils (0.16 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
 - C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 1. Products:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
 - b. Compac Corp.; 130.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
 - d. Venture Tape; 1506 CW NS.
 2. Width: 2 inches (50 mm).

3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive and UL listed.

1. Products:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson o800.
 - b. Compac Corp.; 120.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
 - d. Venture Tape; 3520 CW.
2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products:
 - a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.
2. Width: 3 inches (75 mm).
3. Film Thickness: 4 mils (0.10 mm).
4. Adhesive Thickness: 1.5 mils (0.04 mm).
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products:
 - a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.
2. Width: 3 inches (75 mm).
3. Film Thickness: 6 mils (0.15 mm).
4. Adhesive Thickness: 1.5 mils (0.04 mm).
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

2.14 SECUREMENTS

A. Bands:

1. Products:
 - a. Childers Products; Bands.
 - b. PABCO Metals Corporation; Bands.

- c. RPR Products, Inc.; Bands.
 - 2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 3/4 inch (19 mm) wide with wing or closed seal.
 - 3. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 3/4 inch (19 mm) wide with wing or closed seal.
 - 4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
- B. Insulation Pins and Hangers:
- 1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - a. Products:
 - 1) AGM Industries, Inc.; CWP-1.
 - 2) GEMCO; CD.
 - 3) Midwest Fasteners, Inc.; CD.
 - 4) Nelson Stud Welding; TPA, TPC, and TPS.
 - 2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
 - a. Products:
 - 1) AGM Industries, Inc.; CWP-1.
 - 2) GEMCO; Cupped Head Weld Pin.
 - 3) Midwest Fasteners, Inc.; Cupped Head.
 - 4) Nelson Stud Welding; CHP.
 - 3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Products:
 - 1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
 - 2) GEMCO; Perforated Base.
 - 3) Midwest Fasteners, Inc.; Spindle.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Aluminum, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Products:
 - 1) GEMCO; Nylon Hangers.
 - 2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
 - b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Products:
 - 1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.
 - 2) GEMCO; Press and Peel.
 - 3) Midwest Fasteners, Inc.; Self Stick.
 - b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Aluminum, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Products:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - 4) Nelson Stud Welding; Speed Clips.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

- a. Manufacturers:
 - 1) GEMCO.
 - 2) Midwest Fasteners, Inc.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- D. Wire: 0.080-inch (2.0-mm) nickel-copper alloy
 - 1. Manufacturers:
 - a. ACS Industries, Inc.
 - b. C & F Wire.
 - c. Childers Products.
 - d. PABCO Metals Corporation.
 - e. RPR Products, Inc.

2.15 CORNER ANGLES

- A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.
- C. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or 316.

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.
 - 1. Verify that systems and equipment to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
 - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 COMMON INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Below-Grade Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).
1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Through-Penetration Firestop Systems."
- F. Insulation Installation at Floor Penetrations:
1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
 2. Pipe: Install insulation continuously through floor penetrations.
 3. Seal penetrations through fire-rated assemblies according to Division 7 Section "Through-Penetration Firestop Systems."

3.5 DUCT AND PLENUM INSULATION INSTALLATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 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. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

- a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins 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), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

3.6 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
 - d. Do not overcompress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches (75 mm).
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

- B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
 - 1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 - 2. Seal longitudinal seams and end joints.
- C. Insulation Installation on Pumps:
 - 1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
 - 2. Fabricate boxes from aluminum, at least 0.050 inch (1.3 mm) thick.
 - 3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.7 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this Article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 - 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 - 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 - 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
 - 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.8 CALCIUM SILICATE INSULATION INSTALLATION

- A. Insulation Installation on Boiler Breechings and Ducts:
1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation material.
 2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
 3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.9 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.10 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.

2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.11 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 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. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins 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), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).
 5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.
- F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 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. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins 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 pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.12 PHENOLIC INSULATION INSTALLATION

A. Common Installation Requirements:

1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets with vapor retarders on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.13 POLYISOCYANURATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.14 POLYSTYRENE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed section of polystyrene insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.15 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - 1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 - 2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.
- E. Where PVDC jackets are indicated, install as follows:
 - 1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
 - 2. Wrap factory-presize jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presize jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
 - 3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
 - 4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
 - 5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.16 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous UL-listed fire rating.
- B. Insulate duct access panels and doors to achieve same fire rating as duct.
- C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 7 Section "Through-Penetration Firestop Systems."

3.17 FINISHES

- A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 9 painting Sections.
 - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.18 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent inspecting agency to perform field inspections and prepare inspection reports.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
 - 2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
 - 3. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements. Remove defective Work.
- D. Install new insulation and jackets to replace insulation and jackets removed for inspection. Repeat inspection procedures after new materials are installed.

3.19 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

- 1. Indoor, concealed supply and outdoor air.
- 2. Indoor, exposed supply and outdoor air.
- 3. Indoor, concealed return located in nonconditioned space.
- 4. Indoor, exposed return located in nonconditioned space.
- 5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
- 6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
- 7. Indoor, concealed oven and warewash exhaust.
- 8. Indoor, exposed oven and warewash exhaust.
- 9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
- 10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
- 11. Outdoor, concealed supply and return.
- 12. Outdoor, exposed supply and return.

B. Items Not Insulated:

- 1. Fibrous-glass ducts.
- 2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
- 3. Factory-insulated flexible ducts.
- 4. Factory-insulated plenums and casings.
- 5. Flexible connectors.
- 6. Vibration-control devices.
- 7. Factory-insulated access panels and doors.

3.20 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, supply, return, & outside-air duct insulation shall be any of the following:

- 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
- 2. Mineral-Fiber Board: 1-1/2 inches (38 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

B. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

C. Concealed, supply, return, & outside-air plenum insulation shall be any of the following:

- 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
- 2. Mineral-Fiber Board: 1-1/2 inches (38 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

- D. Exposed, supply, return & outside-air duct insulation shall be the following:
 - 1. Mineral-Fiber Board: 1-1/2 inches (38 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) 3-lb/cu. ft. (48-kg/cu. m) 6-lb/cu. ft. (96-kg/cu. m) nominal density.
- E. Exposed, exhaust-air duct insulation shall be any of the following:
 - 1. Mineral-Fiber Board: 1-1/2 inches (38 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- F. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated board; thickness as required to achieve 2-hour fire rating.
- G. Exposed, supply and return-air plenum insulation shall be the following:
 - 1. Mineral-Fiber Board: 1-1/2 inches (38 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

3.21 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
- B. Supply, Return and Outside-air duct insulation shall be the following:
 - 1. Mineral-Fiber Board: 3 inches (75 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density finish with aluminum jacket.

3.22 EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
- C. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
 - 1. Mineral-Fiber Board: 3 inches thick and 6-lb/cu. ft. nominal density.
 - 2. Polyolefin: 1 inch thick.
- D. Domestic hot-water storage tank insulation shall be either of the following:
 - 1. Mineral-Fiber Board: 4 inches (100 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Pipe and Tank: 4 inches (100 mm) thick.
- E. Breechings
 - 1. Mineral-Fiber Board: 3-1/2 inches thick and 6-lb/cu. ft. nominal density.
 - 2. Provide exterior jacketing on exposed and exterior breeching
- F. Engine-Generator Set Exhaust Pipe
 - 1. Mineral-Fiber Board: 3-1/2 inches thick and 6-lb/cu. ft. nominal density.
- G. Engine-Generator Set Muffler
 - 1. Mineral-Fiber Board: 3-1/2 inches thick and 6-lb/cu. ft. nominal density.

3.23 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Fire-suppression piping.
 - 2. Drainage piping located in crawl spaces.
 - 3. Below-grade piping.
 - 4. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.24 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Hot and Recirculated Hot Water:
 - 1. NPS 1-1/4 and Smaller: Insulation shall be any of the following:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 1 inch thick.
 - c. Mineral-Fiber Pipe Insulation, Type I: 1 inch thick.
 - 2. NPS 1-1/2 and Larger: Insulation shall be any of the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Pipe Insulation, Type I: 1 inch (25 mm) thick.
- B. Stormwater and Overflow, Horizontal Piping and adjacent elbow fittings:
 - 1. All Pipe Sizes: Insulation shall be any of the following:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 1 inch thick.
 - c. Mineral-Fiber Pipe Insulation, Type I: 1 inch thick.
- C. Roof Drain and Overflow Drain Bodies:
 - 1. All Pipe Sizes: Insulation shall be any of the following:
 - a. Mineral-Fiber Pipe Insulation, Type I: 1 inch thick blanket wrap.
- D. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
 - 1. All Pipe Sizes: Insulation shall be any of the following:
 - a. Flexible Elastomeric: 1/2 inch thick.
 - b. Mineral-Fiber Pipe Insulation, Type I: 1/2 inch thick.
- E. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C), Horizontal piping and adjacent elbow fittings, not required in garage exposed areas.

1. All Pipe Sizes: Insulation shall be any of the following:
 - a. Flexible Elastomeric: 3/4 inch (19 mm) thick.
 - F. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
 1. All Pipe Sizes: Insulation shall be any of the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber Pipe Insulation, Type I: 1 inch thick.
 - G. Refrigerant Suction and Hot-Gas Piping:
 1. All Pipe Sizes: Insulation shall be any of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - H. Refrigerant Suction and Hot-Gas Flexible Tubing:
 1. All Pipe Sizes: Insulation shall be either of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - I. Hot Service Drains:
 1. Cellular Glass: 1-1/2 inches thick.
 2. Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch thick.
 - J. Hot Service Vents:
 1. Cellular Glass: 1-1/2 inches thick.
 2. Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch thick
- 3.25 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE
- A. Refrigerant Suction and Hot-Gas Piping:
 1. All Pipe Sizes: Insulation shall be any of the following:
 - a. Flexible Elastomeric: 2 inches (50 mm) thick.
 - B. Refrigerant Suction and Hot-Gas Flexible Tubing:
 1. All Pipe Sizes: Insulation shall be either of the following:
 - a. Flexible Elastomeric: 2 inches (50 mm) thick.
- 3.26 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE
- A. Loose-fill insulation, for belowground piping, is specified in Division 2 piping distribution Sections.

3.27 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Concealed:
 - 1. None.
- D. Ducts and Plenums, Exposed:
 - 1. Aluminum, Smooth 0.024 inch (0.61 mm) thick.
- E. Equipment, Concealed:
 - 1. None.
- F. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
 - 1. Aluminum, Smooth: 0.024 inch (0.61 mm) thick.
- G. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 - 1. Painted, Aluminum, Smooth and Stucco Embossed with 1-1/4-Inch- (32-mm-) Deep Corrugations: 0.032 inch (0.81 mm), 0.040 inch (1.0 mm) thick.
- H. Piping, Concealed:
 - 1. None.
- I. Piping, Exposed:
 - 1. PVC 20 mils (0.5 mm) thick.
 - 2. Aluminum, Smooth 0.024 inch (0.61 mm) thick.
 - 3. Painted Aluminum, Smooth 0.024 inch (0.61 mm) thick.

3.28 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Exposed:
 - 1. Aluminum, Smooth: 0.024 inch (0.61 mm) thick.
- D. Equipment, Concealed:
 - 1. None.

E. Equipment, Exposed:

1. Painted, Aluminum, Smooth: 0.024 inch (0.61 mm) thick.

F. Piping, Concealed:

1. None.

G. Piping, Exposed:

1. Painted ,Aluminum, Smooth: 0.024 inch (0.61 mm) thick.

3.29 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

- A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 230700

SECTION 230800 - COMMISSIONING OF HVAC**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes commissioning process requirements for the following HVAC&R systems, assemblies, and equipment:
 - 1. Energy supply systems, including gas supply.
 - 2. Heat generation systems, including hot-water boilers.
 - 3. Cooling generation systems, including direct-expansion systems.
 - 4. Distribution systems, including air distribution (heating and cooling) systems, hot-water distribution systems, exhaust systems, and air-handling units.
 - 5. Controls and instrumentation, including BAS.
 - 6. Systems testing and balancing verification, including heating-water piping systems, domestic hot-water circulating systems, supply-air systems, return-air systems, and exhaust-air systems.

1.2 DEFINITIONS

- A. BAS: Building automation system.
- B. DDC: Direct digital controls.
- C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.
- D. "Systems," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.
- E. TAB: Testing, adjusting, and balancing.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For BAS and HVAC&R Testing Technician.
- B. Construction Checklists: For the following:
 - 1. Vibration and seismic controls for HVAC&R piping and equipment.
 - 2. Instrumentation and control for HVAC&R.
 - 3. Heating-water piping and accessories.
 - 4. Refrigerant piping.
 - 5. Metal ducts and accessories.
 - 6. Fans.
 - 7. Particulate air filtration.
 - 8. Air-handling units.
 - 9. Boilers.

10. Pumps.

1.4 QUALITY ASSURANCE

- A. BAS Testing Technician Qualifications: Technicians to perform BAS construction checklist verification tests, construction checklist verification test demonstrations, commissioning tests, and commissioning test demonstrations shall have the following minimum qualifications:
 1. Journey-level or equivalent skill level with knowledge of BAS, HVAC&R, electrical concepts, and building operations.
 2. Minimum five years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
 3. International Society of Automation (ISA) Certified Control Systems Technician (CCST) Level I.
- B. HVAC&R Testing Technician Qualifications: Technicians to perform HVAC&R construction checklist verification tests, construction checklist verification test demonstrations, commissioning tests and commissioning test demonstrations shall have the following minimum qualifications:
 1. Journey-level or equivalent skill level. Vocational School four-year program graduate or an Associate's degree in mechanical systems, air conditioning, or similar field. Degree may be offset by three years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC&R systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC&R equipment, assemblies, and systems.
 2. Minimum five years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
 3. One of the following:
 - a. National Environmental Balancing Bureau (NEBB) Certified Testing, Adjusting, and Balancing Technician.
 - b. Associated Air Balance Council (AABC) Certified Test and Balance Technician.
 - c. Owner retains the right to waive NEBB or AABC Certification.
- C. Testing Equipment and Instrumentation Quality and Calibration: For test equipment and instrumentation required to perform HVAC&R commissioning work, perform the following:
 1. Submit test equipment and instrumentation list. For each equipment or instrument, identify the following:
 - a. Equipment/instrument identification number.
 - b. Planned commissioning application or use.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
 2. Test equipment and instrumentation shall meet the following criteria:
 - a. Capable of testing and measuring performance within the specified acceptance criteria.

- b. Be calibrated at the manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 - c. Be maintained in good repair and operating condition throughout the duration of use on this Project.
 - d. Be recalibrated/repared if dropped or damaged in any way since last calibrated.
- D. Proprietary Test Instrumentation and Tools:
 - 1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the commissioning process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, perform the following:
 - a. Submit proprietary instrumentation and tools list. For each instrument or tool, identify the following:
 - 1) Instrument or tool identification number.
 - 2) Equipment schedule designation of equipment for which the instrument or tool is required.
 - 3) Manufacturer, make, model, and serial number.
 - 4) Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.
 - b. Include a separate list of proprietary test instrumentation and tools in the operation and maintenance manuals.
 - c. HVAC&R proprietary test instrumentation and tools become the property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL TESTING REQUIREMENTS

- A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents and approved Shop Drawings and submittals.
- B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.
- C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

- E. Construction Checklists: Prepare and submit detailed construction checklists for HVAC&R systems, subsystems, equipment, and components.
 - 1. Contributors to the development of construction checklists shall include, but are not limited to, the following:
 - a. HVAC&R systems and equipment installers.
 - b. TAB technicians.
 - c. HVAC&R instrumentation and controls installers.
- F. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by Commissioning Coordinator and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 - 2. Commissioning test procedures may direct that set points be altered when simulating conditions is impractical.
 - 3. Commissioning test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- G. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.
- H. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.
- I. Coordinate schedule with, and perform the following activities at the direction of, Commissioning Coordinator.
- J. Comply with construction checklist requirements, including material verification, installation checks, start-up, and performance tests requirements specified in Sections specifying HVAC systems and equipment.
- K. Provide technicians, instrumentation, tools, and equipment to complete and document the following:
 - 1. Performance tests.
 - 2. Demonstration of a sample of performance tests.
 - 3. Commissioning tests.
 - 4. Commissioning test demonstrations.

3.2 TAB COMMISSIONING TESTS

- A. TAB Verification:
 - 1. Conditions of the Test:
 - a. Commissioning Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

- b. Systems operating in full heating mode with minimum outside-air volume.
 - c. Systems operating in full cooling mode with minimum outside-air volume.
 - d. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.
2. Acceptance Criteria:
- a. Under all conditions, rechecked measurements comply with "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
 - b. Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than two times the tolerances allowed.
 - c. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.3 HEATING CONTROL SYSTEM COMMISSIONING TESTS

A. Heating-Water Supply Temperature Control:

1. Prerequisites: Installation verification of the following:
- a. Startup of boiler.
 - b. Startup of heating-water pump(s).
 - c. TAB of heating-water flow and pressure.
 - d. Input Device: Heating-water supply temperature; thermistor temperature sensor.
 - e. Output Device: Control valve.
 - f. Display the following at the operator's workstation:
 - 1) Heating-water supply temperature.
 - 2) Heating-water supply temperature set point.
 - 3) Control-valve position.
2. Conditions of the Test:
- a. Minimum heating-water flow.
 - b. Midrange Heating-Water Flow: 50 to 60 percent of maximum.
 - c. Maximum heating-water flow.
3. Acceptance Criteria: Under all conditions, heating-water supply temperature is within plus or minus 2.0 deg F (1.1 deg C) of set point.

B. Heating-Water Supply Temperature Reset:

1. Prerequisites: Installation verification of the following:
- a. Startup of boiler.
 - b. Startup of heating-water pump(s).
 - c. TAB of heating-water flow and pressure.
 - d. Input Device: Heating-water supply temperature; thermistor temperature sensor.
 - e. Input Device: Outdoor-air temperature; outdoor-air sensor.
 - f. Output Device: Control valve.
 - g. Display the following at the operator's workstation:

- 1) Outdoor-air temperature.
 - 2) Heating-water supply temperature.
 - 3) Heating-water supply temperature set point.
 - 4) Control-valve position.
 2. Conditions of the Test: Outdoor-air temperature input value may be overridden for this test.
 - a. Low Temperature: Outdoor-air temperature between 10°F and below.
 - b. High Temperature: Outdoor-air temperature between 60°F and above.
 3. Acceptance Criteria: Heating-water supply temperature resets in straight-line relationship with outdoor-air temperature for the following reset schedule. Under all conditions, heating-water supply temperature is within 2.0 deg F (1.1 deg C) of set point.
 - a. 180 deg F (90 deg C) heating water when outdoor-air temperature is 10°F or less.
 - b. 140 deg F (54 deg C) heating water when outdoor-air temperature is 60 deg F (18 deg C).
 - c. Under all conditions, heating-water supply temperature is within plus or minus 2.0 deg F (1.1 deg C) of set point.
- C. Control Primary Circulating Pump(s):
 1. Prerequisites: Installation verification of the following:
 - a. Startup of heating-water pump(s).
 - b. Input Device: Outdoor-air temperature; outdoor-air sensor.
 - c. Output Device: Heating-water pump; DDC system command to starter relay.
 - d. Display the following at the operator's workstation:
 - 1) Outdoor-air temperature.
 - 2) Operating status of primary circulating pump(s).
 2. Conditions of the Test:
 - a. High Temperature: Outdoor-air temperature above 60 deg F (18 deg C).
 - b. Low Temperature: Outdoor-air temperature below 60 deg F (18 deg C).
 3. Acceptance Criteria:
 - a. Pumps are energized at all times to maintain constant system pressure.

3.4 DUCT HEATING COILS AND UNIT HEATERS COMMISSIONING TESTS

- A. Duct Heating Coils:
 1. Prerequisites: Installation verification of the following:
 - a. Occupancy Input Device: Occupancy sensor.
 - b. Occupancy Output Device: DDC system binary output.
 - c. Room Temperature Input Device: Electronic temperature sensor.
 - d. Room Temperature Output Device: Electronic control-valve operators.

- e. Display the following at the operator's workstation:
 - 1) Room/area served.
 - 2) Room occupied/unoccupied.
 - 3) Room temperature indication.
 - 4) Room temperature set point.
 - 5) Room temperature set point, occupied.
 - 6) Room temperature set point, unoccupied.
 - 7) Control-valve position as percentage open.
- 2. Conditions of the Test:
 - a. Commissioning Test Demonstration Sampling Rate: 10 percent of each model/size unit.
 - b. Temperature Control - Occupied: Start with the room unoccupied. Occupy the room and observe the change to occupied status. Observe temperature control until room temperature is stable at occupied set point plus or minus 1.0 deg F (0.6 deg C).
 - c. Temperature Control - Unoccupied: Start with the room occupied. Vacate the room and observe the change to unoccupied status. Observe temperature control until room temperature is stable at unoccupied set point plus or minus 1.0 deg F (0.6 deg C).
- 3. Acceptance Criteria:
 - a. Temperature Control - Occupied:
 - 1) Control system status changes from "occupied" to "unoccupied" after the specified time.
 - 2) Room temperature is stable at occupied set point plus or minus 1.0 deg F (0.6 deg C) within 10 minutes of occupancy. Room temperature does not overshoot or undershoot set point by more than 2.0 deg F (1.1 deg C) during transition.
 - b. Temperature Control - Unoccupied:
 - 1) Control system status changes from "unoccupied" to "occupied" immediately.
 - 2) Room temperature is stable at unoccupied set point plus or minus 1.0 deg F (0.6 deg C) within 30 minutes of occupancy.

3.5 AIR-HANDLING SYSTEM COMMISSIONING TESTS

A. Air-Handler Mixed-Air Control:

- 1. Prerequisites: Installation verification of the following:
 - a. Minimum Position Input Device: DDC system time schedule.
 - b. Output Device: DDC system analog output to modulating damper actuator(s).
 - c. Heating Reset Input Device: DDC system software.
 - d. Supply-Air Temperature Input Device: Electronic temperature sensor.
 - e. Cooling Reset Input Device: Outdoor- and return-air, duct-mounted electronic temperature sensors.

- f. Display the following at the operator's workstation:
 - 1) Mixed-air-temperature indication.
 - 2) Mixed-air-temperature set point.
 - 3) Mixed-air damper position.
2. Conditions of the Test:
 - a. Occupied Time Control: Start in unoccupied schedule. Advance to occupied schedule time.
 - b. Minimum Damper Position Control: Command system to mode in which minimum damper position is required.
 - c. Heating Reset Control: Create a call for heating.
 - d. Supply-Air Temperature Control: Override supply-air temperature set point to a value 2.0 deg F (1.1 deg C) above current supply-air temperature.
 - e. Cooling Reset Control: Override outdoor-air temperature to a value that exceeds return-air temperature.
 - f. Unoccupied Time Control: Advance to unoccupied schedule time.
 - g. Control Data Trend Log: Set up a data trend log of the following input device values and output device commands. Record data at 10 minute intervals. Submit trend data for 7 day periods in which natural conditions require heating reset control, supply-air temperature control, and cooling reset control.
 - 1) Minimum position input device.
 - 2) Heating reset input device.
 - 3) Supply-air temperature input device.
 - 4) Cooling reset input device.
3. Acceptance Criteria:
 - a. Occupied Time Control: Mixed-air control is active in occupied mode.
 - b. Minimum Damper Position Control: Controller positions outdoor-air dampers to minimum position.
 - c. Heating Reset Control: Controller sets outdoor-air dampers to minimum position.
 - d. Supply-Air Temperature Control: Controller modulates outdoor-, return-, and relief-air dampers to maintain temporary supply-air temperature set point plus or minus 1.0 deg F (0.6 deg C).
 - e. Cooling Reset Control: Controller sets outdoor-air dampers to minimum position when outdoor-air temperature exceeds return-air temperature.
 - f. Unoccupied Time Control: Controller positions outdoor- and relief-air dampers closed and return-air dampers open.
 - g. Control Data Trend Log: Data verifies control according to sequence of control.

END OF SECTION 230800

SECTION 231123 - FACILITY NATURAL-GAS PIPING**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Valves.
 - 5. Pressure regulators.
 - 6. Service meters.
 - 7. Concrete bases.

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.

1.4 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig (690 kPa) minimum unless otherwise indicated.
 - 2. Service Regulators: 100 psig (690 kPa) minimum unless otherwise indicated.
 - 3. Minimum Operating Pressure of Service Meter: 5 psig (34.5 kPa).
- B. Natural-Gas System Pressure within Buildings: More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa.)

1.5 SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 3. Pressure regulators. Indicate pressure ratings and capacities.
 - 4. Service meters. Indicate pressure ratings and capacities. Include bypass fittings and meter bars [supports.
 - 5. Dielectric fittings.
- B. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.
- C. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.
- D. Welding certificates.
- E. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
- B. 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.
- C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

1.8 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities

occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Construction Manager or Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Construction Manager's or Owner's written permission.

1.9 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe. c. Lapped Face: Not permitted underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
 5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
 6. Mechanical Couplings:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Dresser Piping Specialties; Division of Dresser, Inc.

- 2) Smith-Blair, Inc.
 - b. Steel flanges and tube with epoxy finish.
 - c. Buna-nitrile seals.
 - d. Steel bolts, washers, and nuts.
 - e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
 - f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.
- 7. Steel Mechanical Couplings: Capable of joining steel pipe to steel pipe.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Dresser Piping Specialties; Division of Dresser, Inc.
 - 2) Smith-Blair, Inc.
 - b. Steel flanges and tube with epoxy finish.
 - c. Buna-nitrile seals.
 - d. Stainless-steel bolts, washers, and nuts.
 - e. Factory-installed anode for steel-body couplings installed underground.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

- 1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
- 2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
- 3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
- 4. Corrugated stainless-steel tubing with polymer coating.
- 5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
- 6. End Fittings: Zinc-coated steel.
- 7. Threaded Ends: Comply with ASME B1.20.1.
- 8. Maximum Length: 72 inches (1830 mm).

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

- 1. Copper-alloy convenience outlet and matching plug connector.
- 2. Nitrile seals.
- 3. Hand operated with automatic shutoff when disconnected.
- 4. For indoor or outdoor applications.
- 5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:

- 1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
- 2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
- 3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
- 4. CWP Rating: 125 psig (862 kPa).

D. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

E. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig (5170 kPa).

F. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded- end connection.

2.3 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

- A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
- B. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.
1. CWP Rating: [125 psig (862 kPa).
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for

- valves 1 inch (25 mm) and smaller.
 - 6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.
- C. General Requirements for Metallic Valves, NPS 2-1/2 (DN65) and Larger: Comply with ASME B 16.38.
- 1. CWP Rating: 125 psig (862 kPa).
 - 2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 - 3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - 4. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- D. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP 110.
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. BrassCraft Manufacturing Company; a Masco company.
 - b. Conbraco Industries, Inc.; Apollo Div.
 - c. Lyall, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company.
 - 2. Body: Bronze, complying with ASTM B 584.
 - 3. Ball: Chrome-plated brass.
 - 4. Stem: Bronze; blowout proof.
 - 5. Seats: Reinforced TFE; blowout proof.
 - 6. Packing: Separate packnut with adjustable-stem packing threaded ends.
 - 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - 8. CWP Rating: 600 psig (4140 kPa).
 - 9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- E. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
- 1. Manufacturers: Subject to compliance with requirements available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. BrassCraft Manufacturing Company; a Masco company. b. Conbraco Industries, Inc.; Apollo Div.
 - c. Lyall, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company.
 - 2. Body: Bronze, complying with ASTM B 584.
 - 3. Ball: Chrome-plated bronze.
 - 4. Stem: Bronze; blowout proof.

5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig (4140 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Bronze Plug Valves: MSS SP-78

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

- a. Lee Brass Company.
- b. McDonald, A. Y. Mfg. Co.

2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig (862 kPa).
7. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body. G. Cast-Iron, Lubricat

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

- a. Flowserve.
- b. Homestead Valve; a division of Olson Technologies, Inc.
- c. McDonald, A. Y. Mfg. Co.
- d. Milliken Valve Company.
- e. Mueller Co.; Gas Products Div.
- f. R&M Energy Systems, A Unit of Robbins & Myers, Inc.

2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

H. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.5 MOTORIZED GAS VALVES

A. Automatic Gas Valves: Comply with ANSI Z21.21.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ASCO Power Technologies, LP; Division of Emerson.
 - b. Dungs, Karl, Inc.
 - c. Eaton Corporation; Controls Div.
 - d. Eclipse Combustion, Inc.
 - e. Honeywell International Inc.
 - f. Johnson Controls.
2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless steel.
5. Normally closed.
6. Visual position indicator.
7. Electrical operator for actuation by automatic shutoff device.

2.6 PRESSURE REGULATORS A. General

Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Actaris.
 - b. American Meter Company.
 - c. Fisher Control Valves and Regulators; Division of Emerson Process Management.

- d. Invensys.
 - e. Richards Industries; Jordan Valve Div.
 - 2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 - 3. Springs: Zinc-plated steel; interchangeable.
 - 4. Diaphragm Plate: Zinc-plated steel.
 - 5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 - 6. Orifice: Aluminum; interchangeable.
 - 7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - 8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
 - 9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
 - 10. Overpressure Protection Device: Factory mounted on pressure regulator.
 - 11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - 12. Maximum Inlet Pressure: 100 psig (690 kPa).
- C. Line Pressure Regulators: Comply with ANSI Z21.80.
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Actaris.
 - b. American Meter Company.
 - c. Eclipse Combustion, Inc.
 - d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
 - e. Invensys.
 - f. Maxitrol Company.
 - g. Richards Industries; Jordan Valve Div.
 - 2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 - 3. Springs: Zinc-plated steel; interchangeable.
 - 4. Diaphragm Plate: Zinc-plated steel.
 - 5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 - 6. Orifice: Aluminum; interchangeable.
 - 7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - 8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
 - 9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
 - 10. Overpressure Protection Device: Factory mounted on pressure regulator.
 - 11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - 12. Maximum Inlet Pressure: 2 psig (13.8 kPa).
- D. Appliance Pressure Regulators: Comply with ANSI Z21.18.
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to,

the following:

- a. Canadian Meter Company Inc.
 - b. Eaton Corporation; Controls Div.
 - c. Harper Wyman Co.
 - d. Maxitrol Company.
 - e. SCP, Inc.
2. Body and Diaphragm Case: Die-cast aluminum.
 3. Springs: Zinc-plated steel; interchangeable.
 4. Diaphragm Plate: Zinc-plated steel.
 5. Seat Disc: Nitrile rubber.
 6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
 8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
 9. Maximum Inlet Pressure: 2 psig (13.8 kPa).

2.7 SERVICE METERS

A. Diaphragm-Type Service Meters: Comply with ANSI B109.1 or ANSI B109.2.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Actaris.
 - b. American Meter Company.
 - c. Invensys.
2. Case: Die-cast aluminum.
3. Connections: Steel threads.
4. Diaphragm: Synthetic fabric.
5. Diaphragm Support Bearings: Self-lubricating.
6. Compensation: Continuous temperature and pressure.
7. Meter Index: Cubic feet and liters.
8. Meter Case and Index: Tamper resistant.
9. Remote meter reader compatible.
10. Maximum Inlet Pressure: 100 psig (690 kPa).
11. Pressure Loss: Maximum 0.5-inch wg (124 Pa).
12. Accuracy: Maximum plus or minus 1.0 percent.

B. Service-Meter Bars:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Actaris.
 - b. American Meter Company.
 - c. Lyall, R. W. & Company, Inc.

- d. McDonald, A. Y. Mfg. Co.
 - e. Mueller Co.; Gas Products Div.
 - f. Perfection Corporation; a subsidiary of American Meter Company.
- 2. Malleable- or cast-iron frame for supporting service meter.
 - 3. Include offset swivel pipes, meter nuts with o-ring seal, and factory- or field-installed dielectric unions.
 - 4. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.

C. Service-Meter Bypass Fittings:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Lyall, R. W. & Company, Inc. b. Williamson, T. D., Inc.
- 2. Ferrous, tee, pipe fitting with capped side inlet for temporary natural-gas supply.
- 3. Integral ball-check bypass valve.

2.8 DIELECTRIC FITTINGS

A. Dielectric Unions:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Capitol Manufacturing Company. b. Central Plastics Company.
 - c. Hart Industries International, Inc. d. McDonald, A. Y. Mfg. Co.
 - e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 - f. Wilkins; Zurn Plumbing Products Group.
- 2. Minimum Operating-Pressure Rating: 150 psig (1034 kPa).
- 3. Combination fitting of copper alloy and ferrous materials.
- 4. Insulating materials suitable for natural gas.
- 5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.9 LABELING AND IDENTIFYING

- A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 for installation and purging of natural-gas piping.
- B. Install underground, natural-gas piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
 - 1. If natural-gas piping is installed less than 36 inches (900 mm) below finished grade, install it in containment conduit.
- C. Install underground, PE, natural-gas piping according to ASTM D 2774.
- D. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - 3. Replace pipe having damaged PE coating with new pipe.
- E. Copper Tubing with Protective Coating:
 - 1. Apply joint cover kits over tubing to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
- F. Install fittings for changes in direction and branch connections.

3.4 INDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 for installation and purging of natural-gas piping.

- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. 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.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Verify final equipment locations for roughing-in.
- L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
 2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches (38 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: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
 4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - a. Exception: Tubing passing through partitions or walls does not require striker barriers.
 5. Prohibited Locations:
 - a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - b. Do not install natural-gas piping in solid walls or partitions.
- Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- R. Connect branch piping from top or side of horizontal piping.
- S. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- T. Do not use natural-gas piping as grounding electrode.
- U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."
- 3.5 SERVICE-METER ASSEMBLY INSTALLATION
- A. Install service-meter assemblies aboveground, on concrete bases.
 - B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.

- C. Install strainer on inlet of service-pressure regulator and meter set.
- D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.
- E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.
- F. Install service meters downstream from pressure regulators.
- G. Install metal bollards to protect meter assemblies. Comply with requirements in Division 05 Section "Metal Fabrications" for pipe bollards.

3.6 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
- B. Install underground valves with valve boxes.
- C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- D. Install anode for metallic valves in underground PE piping.

3.7 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

3.8 HANGER AND SUPPORT INSTALLATION

- A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- B. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- C. 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).
 5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (15.8 mm).

3.9 CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

- C. Install piping adjacent to appliances to allow service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.10 LABELING AND IDENTIFYING

- A. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.11 PAINTING

- A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.

3.12 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base.
 - 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. Use 3000-psig (20.7-MPa), 28-day, compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.13 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

- C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.14 OUTDOOR PIPING SCHEDULE

- A. Underground natural-gas piping shall be the following:
 - 1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
- B. Aboveground natural-gas piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.
- C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 kPa).

- A. Aboveground, branch piping shall be the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints. B.
- Aboveground, distribution piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.
- C. Underground, below building, piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.
- D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
- E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

END OF SECTION 23 11 23

SECTION 232300 - REFRIGERANT PIPING**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
 - 2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
 - 3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

1.4 SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
 - 1. Thermostatic expansion valves.
 - 2. Solenoid valves.
 - 3. Hot-gas bypass valves.
 - 4. Filter dryers.
 - 5. Strainers.
 - 6. 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 relationships between piping and equipment.
 - 1. Shop Drawing Scale: 1/4 inch equals 1 foot (1:50).
 - 2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

- C. Welding certificates.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.7 COORDINATION

- A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 88, Type K or L (ASTM B 88M, Type A or B)
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8.
- F. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.

4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.2 REFRIGERANTS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

- A. Suction Lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
- B. Suction Lines NPS 2 to NPS 4 (DN 50 to DN 100) for Conventional Air-Conditioning Applications: Copper, Type L (B), drawn-temper tubing and wrought-copper fittings with brazed joints.
- C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
 1. NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
 2. NPS 2 to NPS 3 (DN 50 to DN 80): Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
 3. NPS 4 (DN 100): Copper, Type K (A), drawn-temper tubing and wrought-copper fittings with soldered joints.
- D. Safety-Relief-Valve Discharge Piping: Copper, Type L (B), drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install diaphragm packless valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.
- E. Install a full-sized, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Hot-gas bypass valves.
 - 4. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve.
- L. Consult refrigeration equipment manufacturer to determine the need for a receiver.
- M. Install receivers sized to accommodate pump-down charge.
- N. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.

- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- L. Install refrigerant piping in protective conduit where installed belowground.
- M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- N. 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.
- O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- P. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
 - 1. Shot blast the interior of piping.
 - 2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
 - 3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
 - 4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
 - 5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
 - 6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.
- Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- R. Seal penetrations through fire and smoke barriers according to Section "Through-Penetration Firestop Systems."
- S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

- T. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- U. Seal pipe penetrations through exterior walls according to Section "Joint Sealants" for materials and methods.
- V. Identify refrigerant piping and valves according to Division 23.

3.4 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.
- F. Threaded Joints: Thread steel 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. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.
- H. Welded Joints: Construct joints according to AWS D10.12/D10.12M.
- I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports."
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 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. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. 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).
 7. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod size, 3/8 inch (9.5 mm).
 8. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
 9. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).
- D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
 2. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch (9.5 mm).
 3. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (9.5 mm).
 4. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).
- E. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
1. Comply with ASME B31.5, Chapter VI.
 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Install core in filter dryers after leak test but before evacuation.
 - 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (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.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Open shutoff valves in condenser water circuit.
 - 2. Verify that compressor oil level is correct.
 - 3. Open compressor suction and discharge valves.
 - 4. Open refrigerant valves except bypass valves that are used for other purposes.
 - 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 232923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes solid-state, pulse-width modulated (PWM), variable frequency controllers (VFCs) for speed control of three-phase, squirrel-cage induction motors.

1.2 SUBMITTALS

- A. Product Data: For each type of VFC.
- B. Shop Drawings: For each VFC.
 - 1. Include wiring diagrams.
- C. Field quality-control test reports.
- D. Operation and maintenance data.
- E. Load-current and overload-relay heater list.
- F. Load-current and list of settings of adjustable overload relays.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100.
- B. Comply with NFPA 70.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.4 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: 0 to 40 deg C.
 - 2. Humidity: Less than 90 percent (noncondensing).

1.5 COORDINATION

- A. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- B. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

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:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
 - 2. Eaton Corporation; Cutler-Hammer Products.
 - 3. General Electric Company; GE Industrial Systems.
 - 4. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.
 - 5. Siemens Energy and Automation; Industrial Products Division.
 - 6. Square D.
 - 7. Toshiba International Corporation.

2.2 VARIABLE FREQUENCY CONTROLLERS

- A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
 - 1. Provide unit suitable for operation of standard-efficiency motor as defined by NEMA MG 1.
- B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- C. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.
- D. Unit Operating Requirements:
 - 1. Input ac voltage tolerance of 380 to 500 V, plus or minus 10 percent.
 - 2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
 - 3. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 4. Minimum Displacement Primary-Side Power Factor: 96 percent.
 - 5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
 - 6. Starting Torque: 100 percent of rated torque or as indicated.

7. Speed Regulation: Plus or minus 1 percent.
- E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
 1. Electrical Signal: 4 to 20 mA at 24 V.
 2. Pneumatic Signal: 3 to 15 psig (20 to 104 kPa).
- F. Internal Adjustability Capabilities:
 1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: 2 to a minimum of 22 seconds.
 4. Deceleration: 2 to a minimum of 22 seconds.
 5. Current Limit: 50 to a minimum of 110 percent of maximum rating.
- G. Self-Protection and Reliability Features:
 1. Input transient protection by means of surge suppressors.
 2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
 3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 10 performance.
 4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 5. Instantaneous line-to-line and line-to-ground overcurrent trips.
 6. Loss-of-phase protection.
 7. Reverse-phase protection.
 8. Short-circuit protection.
 9. Motor overtemperature fault.
- H. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
- I. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.
- J. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- K. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- L. Input Line Conditioning:
- M. VFC Output Filtering:
- N. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
 1. Power on.
 2. Run.
 3. Overvoltage.
 4. Line fault.
 5. Overcurrent.

6. External fault.
- O. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.
- P. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
 1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (VDC).
 9. Set-point frequency (Hz).
 10. Motor output voltage (V).
- Q. Control Signal Interface:
 1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
 2. Pneumatic Input Signal Interface:
 3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
 - a. 0 to 10-V dc.
 - b. 0-20 or 4-20 mA.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 - e. RS485.
 - f. Keypad display for local hand operation.
 4. Output Signal Interface:
 - a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
 - 1) Output frequency (Hz).
 - 2) Output current (load).
 - 3) DC-link voltage (VDC).
 - 4) Motor torque (percent).
 - 5) Motor speed (rpm).
 - 6) Set-point frequency (Hz).
 5. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Set-point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).

- d. PID high- or low-speed limits reached.
- R. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
- S. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).
- T. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.
- U. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker with lockable handle.
- V. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.
- W. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.3 ENCLOSURES

- A. Provide weatherproof NEMA 3R enclosure.

2.4 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Standard Displays:
 - 1. Output frequency (Hz).
 - 2. Set-point frequency (Hz).
 - 3. Motor current (amperes).
 - 4. DC-link voltage (VDC).
 - 5. Motor torque (percent).
 - 6. Motor speed (rpm).
 - 7. Motor output voltage (V).

- F. Historical Logging Information and Displays:
 - 1. Real-time clock with current time and date.
 - 2. Running log of total power versus time.
 - 3. Total run time.
 - 4. Fault log, maintaining last four faults with time and date stamp for each.
- G. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

2.5 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to VFCs before shipping.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.
- B. Select horsepower rating of controllers to suit motor controlled.

3.2 INSTALLATION

- A. Install VFCs on concrete bases.
- B. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- C. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.3 IDENTIFICATION

- A. Identify VFCs, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."
- B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.4 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
 - 1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
 - 2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - 1. Inspect controllers, wiring, components, connections, and equipment installation.
 - 2. Assist in field testing of equipment.
 - 3. Report results in writing.
- C. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.6 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

END OF SECTION 23 29 23

SECTION 233113 - METAL DUCTS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this 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, and flat-oval spiral-seam ducts and formed fittings.
 - 3. Duct liner.

1.3 DEFINITIONS

- A. FRP: Fiberglass-reinforced plastic.

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 layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.5 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.6 SUBMITTALS

- A. Product Data: For each type of the following products:

- 1. Liners and adhesives.
- 2. Sealants and gaskets.
- 3. Seismic-restraint devices (if required).

- B. Shop Drawings:

- 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
- 2. Factory- and shop-fabricated ducts and fittings.
- 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
- 4. Elevation of top of ducts.
- 5. Dimensions of main duct runs from building grid lines.
- 6. Fittings.
- 7. Reinforcement and spacing.
- 8. Seam and joint construction.
- 9. Penetrations through fire-rated and other partitions.
- 10. Equipment installation based on equipment being used on Project.
- 11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
- 12. Hangers and supports, including methods for duct and building attachment and vibration isolation.
- 13. Smoke and fire dampers
- 14. Soil, waste and vent piping
- 15. Medical gas piping
- 16. Roof drain piping
- 17. Domestic water piping
- 18. Sprinkler piping and heads
- 19. First paragraph below is defined in Division 1 Section "Submittal Procedures" as a "Delegated-Design Submittal." Retain with "Performance Requirements" Article if design responsibilities have been delegated to Contractor.

- C. Delegated-Design Submittal:

- 1. Sheet metal thicknesses.
- 2. Joint and seam construction and sealing.
- 3. Reinforcement details and spacing.
- 4. Materials, fabrication, assembly, and spacing of hangers and supports.
- 5. Design Calculations: Calculations for selecting hangers and supports.

- D. The Sheetmetal Subcontractor shall prepare a complete set of CAD generated background drawings on mylar sheet material at a scale not less than 3/8" equals 1'-0", showing structure, owner furnished equipment, etc., and other information as needed for coordination and noted above. He shall show sheetmetal layout thereon. These will be the Coordination Drawings.

- E. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 2. Suspended ceiling components.
 3. Structural members to which duct will be attached.
 4. Size and location of initial access modules for acoustical tile.
 5. Penetrations of smoke barriers and fire-rated construction.
 6. All firewalls and smoke partitions must be highlighted for appropriate coordination.
 7. The main paths of egress and for equipment removal, from main mechanical/electrical rooms must be clearly shown
 8. Illustrate clear maintenance access, coil pull, and code required clearance for all equipment
 9. Illustrate code minimum required clearances between miscellaneous vents, exhaust air outlets and outdoor air intakes.
 10. Coordinate final location of floor drains with housekeeping pads and equipment locations.
 11. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.
 12. Where conflicts occur with placement of materials of various trades, the Sheetmetal Subcontractor will be responsible to coordinate the available space to accommodate all trades. Any resulting adjustments shall be initialed and dated by the specialty trade. The Sheetmetal Subcontractor shall then final date and sign each drawing. If he cannot resolve conflicts, the decision of the General Contractor shall be final.
 13. After Approval:
 - a. All changes to approved coordination drawings shall be approved in writing by the Architect/Engineer prior to start of work in affected areas.
- F. Welding certificates.
- G. Field quality-control test reports.

1.7 DESIGN CRITERIA

- A. All ventilation system products provided for this project shall conform to NFPA Section 90A, possessing a flame spread rating of not over 25 and a smoke developed rating no higher than 50.
- B. All ductwork shall be installed as close as possible to wall and underside of beams and joists. Maintain 6" minimum clearance from rated walls.
- C. Provide access for fire dampers and smoke detectors in ductwork.

- D. Provide access panels up stream of all elbows with turning vanes and on discharge side of electrical heaters.
- E. Provide access panels in ductwork for operation, adjustment and maintenance of all fans, valves and mechanical equipment.
- F. Ceiling access panels shall be provided, where required, to service dampers, heaters, valves and other concealed mechanical equipment.
- G. The inside of all ductwork visible through a grille or diffuser shall be painted flat black.

1.8 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. NFPA Compliance:
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- C. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Ch. 3, "Duct System," for range hood ducts, unless otherwise indicated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support

intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Lindab Inc.
 - b. McGill AirFlow LLC.
 - c. SEMCO Incorporated.
 - d. Sheet Metal Connectors, Inc.
 - e. Spiral Manufacturing Co., Inc.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
 - 2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
- D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

- A. 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 G60 (Z180) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. PVC-Coated Galvanized Steel: Acceptable by authorities having jurisdiction for use in fabricating ducts with UL 181, Class 1 listing. Lock-forming-quality, galvanized sheet steel complying with ASTM A 653/A 653M and having G60 (Z180) coating designation. Factory-applied PVC coatings shall be 4 mils (0.10 mm) thick on sheet metal surfaces of ducts and fittings exposed to corrosive conditions and 2 mils (0.05 mm) thick on opposite surfaces.
- D. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.
- E. Stainless Steel: ASTM A 480/A 480M, Type 316 and having a No. 2D finish for concealed ducts and minimum No. 2 finish for exposed ducts.
- F. Aluminum Sheets: ASTM B 209 (ASTM B 209M), alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- G. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
- H. 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).

2.5 DUCT LINER

- A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
 - 1. Manufacturers:
 - a. CertainTeed Corp.; Insulation Group.
 - b. Johns Manville International, Inc.
 - c. Knauf Fiber Glass GmbH.
 - d. Owens Corning.
 - 2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
 - a. Thickness: 1 inch (25 mm)
 - b. Thermal Conductivity (k-Value): 0.26 at 75 deg F (0.037 at 24 deg C) mean temperature.
 - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

- d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
- e. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.
 - 1) Tensile Strength: Indefinitely sustain a 50-lb- (23-kg-) tensile, dead-load test perpendicular to duct wall.
 - 2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch (3 mm) into airstream.
 - 3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

2.6 SEALANT MATERIALS

- A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
- B. Joint and Seam Tape: 2 inches (50 mm) wide; glass-fiber-reinforced fabric.
- C. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
- D. 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.
- E. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.
- F. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- G. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.7 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. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - 2. 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.

2.8 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.
1. Duct Size: Maximum 30 inches (750 mm) wide and up to 2-inch wg (500-Pa) pressure class.
 2. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.
- 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.

2.9 APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
- B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
- C. Butt transverse joints without gaps and coat joint with adhesive.

- D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s).
- G. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
- H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - 1. Fan discharges.
 - 2. Intervals of lined duct preceding unlined duct.
 - 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm (12.7 m/s) or where indicated.
- I. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
 - 1. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.
- J. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.10 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

- A. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.
- B. Round, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- C. Flat-Oval, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Fabricate ducts larger than 72 inches (1830 mm) in diameter with butt-welded longitudinal seams.
- 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. Ducts Larger Than 72 Inches (1830 mm) in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
 4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.
 5. Flat-Oval Ducts: Prefabricated connection system consisting of two flanges and one synthetic rubber gasket.
- E. 90-Degree Tees and Laterals and Conical Tees: 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," unless otherwise indicated.
 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).
 - b. Ducts 37 to 50 Inches (940 to 1270 mm) in Diameter: 0.040 inch (1.0 mm).
 - c. Ducts 52 to 60 Inches (1320 to 1525 mm) in Diameter: 0.052 inch (1.3 mm).
 - d. Ducts 62 to 84 Inches (1575 to 2130 mm) in Diameter: 0.064 inch (1.6 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).
 - b. Ducts 27 to 50 Inches (685 to 1270 mm) in Diameter: 0.040 inch (1.0 mm).
 - c. Ducts 52 to 60 Inches (1320 to 1525 mm) in Diameter: 0.052 inch (1.3 mm).
 - d. Ducts 62 to 84 Inches (1575 to 2130 mm) in Diameter: 0.064 inch (1.6 mm).
 4. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal-seam flat-oval duct.
 5. 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.
 6. Round Elbows 8 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.
 7. 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.

8. Round Elbows Larger Than 14 Inches (355 mm) in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
 9. Die-Formed Elbows for Sizes through 8 Inches (200 mm) in Diameter and All Pressures 0.040 inch (1.0 mm) thick with 2-piece welded construction.
 10. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
 11. Flat-Oval Elbow Metal Thickness: Same as longitudinal-seam flat-oval duct specified above.
 12. 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).
- H. PVC-Coated Elbows and Fittings: Fabricate elbows and fittings as follows:
1. Round Elbows 4 to 8 Inches (100 to 200 mm) in Diameter: Two piece, die stamped, with longitudinal seams spot welded, bonded, and painted with PVC aerosol spray.
 2. Round Elbows 9 to 26 Inches (225 to 660 mm) in Diameter: Standing-seam construction.
 3. Round Elbows 28 to 60 Inches (710 to 1525 mm) in Diameter: Standard gored construction, riveted and bonded.
 4. Other Fittings: Riveted and bonded joints.
 5. Couplings: Slip-joint construction with a minimum 2-inch (50-mm) insertion length.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

- A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
1. Supply Ducts (in Mechanical Equipment Rooms): 2-inch wg (500 Pa)
 2. Return Ducts (in Mechanical Equipment Rooms): 1-inch wg (250 Pa).
 3. Exhaust Ducts (Negative Pressure): 1-inch wg (250 Pa).

3.2 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- C. Install round and flat-oval ducts in lengths not less than 12 feet (3.7 m) unless interrupted by fittings.
- D. Install ducts with fewest possible joints.
- E. Install fabricated fittings for changes in directions, size, and shape and for connections.

- F. 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.
- G. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- I. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- J. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
- K. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
- L. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- M. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- N. 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).
- O. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 7 Section "Through-Penetration Firestop Systems."
- P. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."
- Q. 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 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.4 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class C.
 - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
 - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
 - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
 - 8. Unconditioned Space, Return-Air Ducts: Seal Class B.
 - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
 - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
 - 11. Conditioned Space, Exhaust Ducts: Seal Class B.
 - 12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

- 5. Do not use powder-actuated concrete fasteners for seismic restraints.
 - C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.
 - D. Hangers Exposed to View: Threaded rod and angle or channel supports.
 - E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).
 - F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- 3.6 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.
 - 1. For pressure classes lower than 2-inch wg (500 Pa), seal transverse joints.
 - B. Seal ducts before external insulation is applied.
- 3.7 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 concrete inserts before placing concrete.
 - E. 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.
- 3.8 CONNECTIONS
- A. Make connections to equipment with flexible connectors according to Division 23 Section "Duct Accessories."

- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.9 FIELD QUALITY CONTROL

- A. 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. If pressure classes are not indicated, test entire system at maximum system design pressure. 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 and flat-oval 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).
 - 4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.
 - 5. Test the following systems:
 - a. Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - b. Supply Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - c. Return Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections no less than 50 percent of total installed duct area for each designated pressure class.
 - d. Exhaust Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections no less than 50 percent of total installed duct area for each designated pressure class.
 - e. Outside Air Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections no less than 50 percent of total installed duct area for each designated pressure class.
 - 6. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 7. Test for leaks before applying external insulation.
 - 8. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - 9. Give seven days' advance notice for testing.
- B. Duct System Cleanliness Tests:
 - 1. Visually inspect duct system to ensure that no visible contaminants are present.
 - 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

- a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- C. Duct system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.10 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 9 painting Sections.

3.11 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.

3.12 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply, Outdoor Air, and Return Ducts:

1. Ducts Connected to Fan Coil Units, and Terminal Units:
 - a. Pressure Class: Positive 1-inch wg (250 Pa).
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. Material: Galvanized Steel Duct.
2. Ducts Connected to Constant-Volume Air-Handling Units:
 - a. Pressure Class: Positive 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. Material: Galvanized Steel Duct.

C. Exhaust Ducts (General):

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. Material: Galvanized Steel Duct.

D. Exhaust Ducts:

1. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.
 - a. Exposed to View: Type 304, stainless-steel sheet.
 - b. Concealed: Type 304, stainless-steel sheet, No. 2D finish.
 - c. Welded seams and joints.
 - d. Pressure Class: Positive or negative 3-inch wg (750 Pa).
 - e. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
 - f. SMACNA Leakage Class: 3.

2. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Negative 2-inch wg (500 Pa)
 - b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 12
 - d. SMACNA Leakage Class for Round and Flat Oval: 6
- E. Bath or Shower Exhaust Ducts:
 1. Use aluminum sheet with all joints and seams sealed with duct sealant or welded for water tightness.
 2. Use aluminum duct for exhaust from bath or shower rooms if they contain more than one bath tub or more than one shower head. The aluminum duct shall extend from the individual exhaust grilles to the exhaust fan. The exhaust fan discharge ductwork shall be aluminum or galvanized steel. All aluminum exhaust duct from the individual exhaust grilles to the exhaust fan shall be sealed with duct sealant or welded for water tightness.
- F. Sterilizer Exhaust Ducts:
 1. Use aluminum duct for exhaust from sterilizer piping spaces and for exhaust ducts and hoods located above sterilizer doors. All associated exhaust ductwork shall be air and water tight by means of duct sealant or welding.
 2. Pitch ductwork back toward equipment.
- G. Intermediate Reinforcement:
 1. Galvanized-Steel Ducts: Galvanized steel.
 2. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.
 3. Aluminum Ducts: Aluminum.
- H. Liner:
 1. Supply Air Ducts: Fibrous glass, Type I 1-1/2 inches (38 mm) thick.
 2. Return Air Ducts: Fibrous glass, Type I 1-1/2 inches (38 mm) thick.
 3. Exhaust Air Ducts: Fibrous glass, Type I 1-1/2 inches (38 mm) thick.
 4. Supply Fan Plenums: Fibrous glass, Type I 1-1/2 inches (38 mm) thick.
 5. Return- and Exhaust-Fan Plenums: Fibrous glass, Type I 1-1/2 inches (38 mm) thick.
 6. Transfer Ducts: Fibrous glass, Type I 1-1/2 inches (38 mm) thick.
- I. Double-Wall Duct Interstitial Insulation (First 15' of AHU/RTU supply):
 1. Supply and Return Air Ducts: 1-1/2 inches (38 mm) thick.
- J. Elbow Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm (5 m/s) or Lower:

- 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm (7.6 m/s) or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam.
- K. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."

- a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
- a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
 - c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233116 - NONMETAL DUCTS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Fibrous-glass ducts and fittings.
- B. Related Sections:
 - 1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for nonmetal ducts.
 - 2. Division 23 Section "Metal Ducts" for single- and double-wall, rectangular and round ducts.
 - 3. Division 23 Section "Air Duct Accessories" for dampers, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Fibrous-glass duct materials.
- B. Shop Drawings:
 - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - 2. Duct layout indicating sizes and pressure classes.
 - 3. Elevation of top of ducts.
 - 4. Dimensions of main duct runs from building grid lines.
 - 5. Fittings.
 - 6. Reinforcement and spacing.
 - 7. Seam and joint construction.
 - 8. Penetrations through fire-rated and other partitions.
 - 9. Equipment installation based on equipment being used on Project.
 - 10. Hangers and supports, including methods for duct and building attachment and vibration isolation.
- C. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 2. Suspended ceiling components.
 3. Structural members to which duct will be attached.
 4. Size and location of initial access modules for acoustical tile.
 5. Penetrations of smoke barriers and fire-rated construction.
 6. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.
- D. Welding certificates.
- E. Field quality-control reports.
- 1.4 QUALITY ASSURANCE
- A. NFPA Compliance:
1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 FIBROUS-GLASS DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. CertainTeed Corporation; Insulation Group.
 2. Johns Manville.
 3. Knauf Insulation.
 4. Owens Corning.
- B. Fibrous-Glass Duct Materials: Resin-bonded fiberglass, faced on the outside surface with fire-resistive FSK vapor retarder and with a smooth fiberglass mat finish on the air-side surface.
1. Duct Board: Factory molded into rectangular boards.
 2. Temperature Limits: 40 to 250 deg F inside ducts; 150 deg F ambient temperature surrounding ducts.
 3. Maximum Thermal Conductivity: 0.26 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 4. Moisture Absorption: Not exceeding 5 percent by weight at 120 deg F and 95 percent relative humidity for 96 hours when tested according to ASTM C 1104/C 1104M.
 5. Permeability: 0.02 perms maximum when tested according to ASTM E 96/E 96M, Procedure A.

6. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C 423, Mounting A.

C. Closure Materials:

1. Two-Part Tape Sealing System: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-M," the manufacturer's name, and a date code.
 - a. Tape: Woven glass fiber impregnated with mineral gypsum.
 - b. Minimum Tape Width: 3 inches.
 - c. Sealant: Modified styrene acrylic.
 - d. Water resistant.
 - e. Mold and mildew resistant.
 - f. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Fabrication:

1. Select joints, seams, transitions, elbows, and branch connections and fabricate according to SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 2, "Specifications and Closure," and Chapter 4, "Fittings and Connections.
2. Fabricate 90-degree mitered elbows to include turning vanes.
3. Reinforcements: Comply with requirements in SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 5, "Reinforcement" for channel- and tie-rod reinforcement materials, spacing, and fabrication.
4. Preformed Round Duct: Comply with NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section VII, "Preformed Round Duct."

2.2 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables: ASTM A 603, galvanized or ASTM A 492, stainless steel with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- F. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Install ducts with fewest possible joints.
- B. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- C. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- D. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- E. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges. Overlap openings on four sides by at least 1-1/2 inches.
- F. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- G. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."
- H. Install fibrous-glass ducts and fittings to comply with SMACNA's "Fibrous Glass Duct Construction Standards."

3.2 HANGER AND SUPPORT INSTALLATION

- A. Install hangers and supports for fibrous-glass ducts and fittings to comply with SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 6, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
- C. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 FIELD QUALITY CONTROL

- A. Duct System Cleanliness Tests:
 - 1. Visually inspect duct system to ensure that no visible contaminants are present.
 - 2. Test sections of nonmetal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

- B. Duct system will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.4 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
 - 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch duct as recommended by duct manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. Particulate Collection and Odor Control:
 - 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- D. Clean the following components by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.
 - 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:
 - 1. 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.
 - 2. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of ducts or duct accessories.
 - 3. Clean fibrous-glass duct with HEPA vacuuming equipment; do not permit duct to get wet. Replace fibrous-glass duct that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 - 4. 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.

5. Provide drainage and cleanup for wash-down procedures.
6. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.5 START UP

- A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

END OF SECTION 233116

SECTION 233300 - AIR DUCT ACCESSORIES**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Backdraft dampers.
 - 2. Volume dampers.
 - 3. Motorized control dampers.
 - 4. Fire Dampers
 - 5. Combination Fire and Smoke Dampers
 - 6. Turning vanes.
 - 7. Duct-mounting access doors.
 - 8. Flexible connectors.
 - 9. Flexible ducts.
 - 10. Duct accessory hardware.
- B. Related Sections include the following:
 - 1. Division 23 Section "Instrumentation and Controls" for electric damper actuators.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Backdraft dampers.
 - 2. Volume dampers.
 - 3. Motorized control dampers.
 - 4. Turning vanes.
 - 5. Duct-mounting access doors.
 - 6. Flexible connectors.
 - 7. Flexible ducts.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Special fittings.
 - 2. Manual-volume damper installations.
 - 3. Motorized-control damper installations.

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 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. Stainless Steel: ASTM A 480/A 480M.
- D. Aluminum Sheets: ASTM B 209 (ASTM B 209M), alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- E. Extruded Aluminum: ASTM B 221 (ASTM B 221M), alloy 6063, temper T6.
- F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- G. Tie Rods: Galvanized steel, 1/4-inch (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).

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers:
 - 1. Air Balance, Inc.
 - 2. American Warming and Ventilating.
 - 3. CESCO Products.
 - 4. Duro Dyne Corp.
 - 5. Greenheck.
 - 6. Penn Ventilation Company, Inc.
 - 7. Prefco Products, Inc.
 - 8. Ruskin Company.
 - 9. Vent Products Company, Inc.
- B. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6-inch (150-mm) width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.
- C. Frame: 0.063-inch- (1.6-mm-) thick extruded aluminum, with welded corners and mounting flange.

- D. Blades: 0.025-inch- (0.6-mm-) thick, roll-formed aluminum
- E. Blade Seals: Vinyl
- F. Blade Axles: Nonferrous
- G. Tie Bars and Brackets: Aluminum.
- H. Return Spring: Adjustable tension.

2.3 VOLUME DAMPERS

- A. Manufacturers:
 - 1. Air Balance, Inc.
 - 2. American Warming and Ventilating.
 - 3. Flexmaster U.S.A., Inc.
 - 4. McGill AirFlow Corporation.
 - 5. METALAIRE, Inc.
 - 6. Nailor Industries Inc.
 - 7. Penn Ventilation Company, Inc.
 - 8. Ruskin Company.
 - 9. Vent Products Company, Inc.
- B. 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.
- C. 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: Oil-impregnated bronze.
 - 8. Tie Bars and Brackets: Aluminum.
 - 9. Tie Bars and Brackets: Galvanized steel.

- D. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-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: Oil-impregnated bronze thrust or ball.
 - 8. Blade Seals: Vinyl .
 - 9. Jamb Seals: Cambered aluminum.
 - 10. Tie Bars and Brackets: Aluminum.
- E. 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.
- F. 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. Manufacturers:
 - 1. Air Balance, Inc.
 - 2. American Warming and Ventilating.
 - 3. CESCO Products.
 - 4. Duro Dyne Corp.
 - 5. Greenheck.
 - 6. McGill AirFlow Corporation.
 - 7. METALAIRE, Inc.
 - 8. Nailor Industries Inc.
 - 9. Penn Ventilation Company, Inc.
 - 10. Ruskin Company.
 - 11. Vent Products Company, Inc.
- B. 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 FIRE DAMPERS

A. Manufacturers:

- 4. Air Balance, Inc.
- 5. CESCO Products.
- 6. Greenheck.
- 7. McGill AirFlow Corporation.
- 8. METALAIR, Inc.
- 9. Nailor Industries Inc.
- 10. Penn Ventilation Company, Inc.
- 11. Prefco Products, Inc.
- 12. Ruskin Company.
- 13. Vent Products Company, Inc.
- 14. Ward Industries, Inc.

B. Fire dampers shall be labeled according to UL 555.

C. Fire Rating: 1-1/2 hours.

C. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.

D. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

- 1. Minimum Thickness: 0.052 or 0.138 inch (1.3 or 3.5 mm) thick as indicated and of length to suit application.
- 2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

E. Mounting Orientation: Vertical or horizontal as indicated.

F. Blades: Roll-formed, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.

G. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

H. Fusible Links: Replaceable, 165 deg F (74 deg C) rated.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
 2. CESCO Products.
 3. Greenheck.
 4. Nailor Industries Inc.
 5. Penn Ventilation Company, Inc.
 6. Ruskin Company.
- B. Combination fire and smoke dampers shall include automatic-reopening types to be part of an engineered smoke control system.
- C. General Description: Combination fire and smoke dampers shall be labeled according to UL 555 for 1-1/2-hour rating.
- D. When smoke is detected (via a smoke detector), during testing or if power failure occurs, the damper will close and remain closed. When the smoke signal ceases (smoke detector reset), the test is completed or power is restored the damper will automatically RESET to the open position. The damper automatically resets if nuisance alarms occur and the system is reset.
- E. The position of the damper to be shown in the fire command center or on a separate control panel. When closed, the damper CLOSED indicator light (on the separate control panel or in the fire command center) will light. The damper remains closed until an override signal for smoke management is initiated and the duct temperature has not exceeded the high limit.
- F. A High Limit Temperature Sensor prevents the damper from reopening when duct temperature is above damper's UL555S degradation test temperature of 250°F/121°C or 350°F/177°C.
- G. Upon cessation of the fire conditions, the damper can be reopened by pressing the RESET button located on the damper assembly.
- H. Frame and Blades: 0.064-inch- (1.62-mm-) thick, galvanized sheet steel.
- I. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.
- J. Damper Motors: Modulating and two-position action.
1. Comply with requirements in Division 15 Section "Motors."
 2. Electrical Connection: 115 V, single phase, 60 Hz.
- 2.7 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, single-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 into vane runners suitable for duct mounting.
1. Manufacturers:
 - a. Ductmate Industries, Inc.
 - b. Duro Dyne Corp.

- c. METALAIRE, Inc.
 - d. Ward Industries, Inc.
- C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.8 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. Manufacturers:
 - 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.
 - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 3. 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.
 - d. Sizes 24 by 48 Inches (600 by 1200 mm) and Larger: One additional hinge.
- C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch (25-mm) thickness. Include cam latches.
 - 1. Manufacturers:
 - a. Ductmate Industries, Inc.
 - b. Flexmaster U.S.A., Inc.
 - 2. Frame: Galvanized sheet steel, with spin-in notched frame.
- D. Pressure Relief Access Door: Single wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain.
 - 1. Manufacturers:
 - a. American Warming and Ventilating.
 - b. CESCO Products.

- c. Ductmate Industries, Inc.
 - d. Greenheck.
 - e. KEES, Inc.
 - f. McGill AirFlow Corporation.
 - g. Nexus PDQ.
- 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
- E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.
- F. Insulation: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.9 FLEXIBLE CONNECTORS

- A. Manufacturers:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Corp.
 - 3. Ventfabrics, Inc.
 - 4. Ward Industries, Inc.
- B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches (146 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.
- D. 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 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
- E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
 - 2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).
- F. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - 1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
 - 2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
- G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

2.10 FLEXIBLE DUCTS (NON MEDICAL GRADE)

- A. Manufacturers: Subject to compliance with requirements:
1. Flexmaster U.S.A., Inc.
 2. McGill AirFlow LLC.
 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
1. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
 2. Maximum Air Velocity: 4000 fpm (20 m/s).
 3. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).
 4. Insulation R-Value: Comply with ASHRAE/IESNA 90.1-2004
- C. Flexible Duct Connectors:
1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.
 2. Non-Clamp Connectors: Liquid adhesive plus tape

2.11 FLEXIBLE DUCTS (NON MEDICAL GRADE)

- A. Prohibited unless specifically noted on plans.
- B. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene 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 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
- C. Insulated-Duct Connectors: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.
1. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
 2. Maximum Air Velocity: 4000 fpm (20.3 m/s).
 3. Temperature Range: Minus 20 to plus 175 deg F (Minus 28 to plus 79 deg C).
- D. Insulated-Duct Connectors: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.
1. Pressure Rating: 10-inch wg (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).

- E. Flexible Duct Clamps: Nylon strap, in sizes 3 through 18 inches (75 to 450 mm) to suit duct size.

2.12 DUCT ACCESSORY HARDWARE

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

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- D. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.
- E. 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.
- F. Provide test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
 - 1. On both sides of duct coils.
 - 2. Downstream from volume dampers, turning vanes, and equipment.
 - 3. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot (15-m) spacing.
 - 4. On sides of ducts where adequate clearance is available.
- H. 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).

- I. 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.
- J. 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.
- K. Label access doors according to Division 15 Section "Mechanical Identification."
- L. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
- M. 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.
- N. Connect terminal units to supply ducts with maximum 12-inch (300-mm) lengths of flexible duct. Do not use flexible ducts to change directions.
- O. Connect diffusers or light troffer boots to low pressure ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.
- P. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- Q. 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 23 Section "Testing, Adjusting, and Balancing."

END OF SECTION 233300

SECTION 233423 - HVAC 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.

1.2 SUMMARY

- A. This Section includes the following:

- 1. Utility Set fans.
- 2. Centrifugal roof ventilators.
- 3. Ceiling-mounting ventilators.
- 4. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on 100' sea level.
- B. 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 thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Roof curbs.
 - 7. Fan speed controllers.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
 - 2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

- 3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
- C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Roof framing and support members relative to duct penetrations.
 - 2. Ceiling suspension assembly members.
 - 3. Size and location of initial access modules for acoustical tile.
 - 4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

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

- C. 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(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 UTILITY SET FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carnes Company HVAC.
 - 2. Greenheck
 - 3. Loren Cook Company.
 - 4. New York Blower Company (The).
 - 5. Penn Ventilation.
 - 6. Trane.
- B. Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.
- C. Housing: Fabricated of galvanized steel with side sheets continuously or welded to scroll sheets.
 - 1. Housing Discharge Arrangement: Upward.
- D. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.
 - 1. Blade Materials: Steel.
 - 2. Blade Type: Airfoil.
 - 3. Spark-Resistant Construction: AMCA 99, Type A.
- E. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
- F. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L₅₀ of 200,000 hours.
- G. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
 - 1. Service Factor Based on Fan Motor Size: 1.5.
 - 2. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - 3. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

4. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

H. Accessories:

1. UL Label – Power ventilator for smoke control systems at 500°F (260°C) for a minimum of 4 hours and 1000°F (537°C) for a minimum of 15 years.
2. Inlet and Outlet: Flanged.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Access Door: Gasketed door in scroll with latch-type handles.
5. Drain Connections: NPS 3/4 (DN 20) threaded coupling drain connection installed at lowest point of housing.
6. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
7. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

I. Coatings: Powder-baked enamel.

1. Vibration Isolators:
 - a. Type: Restrained spring isolators.
 - b. Static Deflection: 3 inches.
2. Spark Arrestance Class: A.

2.2 CENTRIFUGAL ROOF VENTILATORS

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

1. Acme Engineering & Mfg. Corp.
2. Broan Mfg. Co., Inc.
3. Carnes Company HVAC.
4. Greenheck.
5. Loren Cook Company.
6. NuTone Inc.
7. Penn Ventilation.
8. Quietaire Corporation.

B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain drain and grease collector.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust airstream.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside outside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 12 inches (300 mm).
3. Sound Curb: Curb with sound-absorbing insulation matrix.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.

2.3 CEILING-MOUNTING VENTILATORS

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

1. Broan Mfg. Co., Inc.
2. Carnes Company HVAC.
3. Greenheck.
4. Loren Cook Company.
5. NuTone Inc.
6. Penn Ventilation.

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

C. Housing: Steel, lined with acoustical insulation.

D. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

- E. Grille: Painted aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.
- F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
- G. Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
 - 3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
 - 4. Motion Sensor: Motion detector with adjustable shutoff timer.
 - 5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
 - 6. Filter: Washable aluminum to fit between fan and grille.
 - 7. Isolation: Rubber-in-shear vibration isolators.
 - 8. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.4 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Acme Engineering & Mfg. Corp.
 - 2. Breidert Air Products.
 - 3. Carnes Company HVAC.
 - 4. Greenheck.
 - 5. Loren Cook Company.
 - 6. Penn Ventilation.
 - 7. Quietaire Corporation.
- B. Description: In-line, direct or belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
- C. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- D. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing;
- E. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- F. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- G. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
3. Companion Flanges: For inlet and outlet duct connections.
4. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.5 MOTORS

- A. Enclosure Type: Totally enclosed, fan cooled.

2.6 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. Support units using restrained elastomeric mounts or spring isolators having a static deflection of 1 inch (25 mm). Vibration- devices are specified in Division 15 Section "Mechanical Vibration Controls."
 1. Secure vibration controls to concrete bases using anchor bolts cast in concrete base.
- C. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 7 Section "Roof Accessories" for installation of roof curbs.
- D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- E. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops having a static deflection of 1 inch (25 mm) . Vibration-control devices are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."
- F. Install units with clearances for service and maintenance.
- G. 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 according to Division 16 Section "Grounding and Bonding."
- D. Connect wiring according to Division 16 Section "Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that 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. Adjust belt tension.
 - 6. Adjust damper linkages for proper damper operation.
 - 7. Verify lubrication for bearings and other moving parts.
 - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - 10. Shut unit down and reconnect automatic temperature-control operators.
 - 11. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

END SECTION 23 34 23

SECTION 233713 - 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.

1.2 SUMMARY

- A. This Section includes ceiling- and wall-mounted 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.
- B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.
- C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.
- D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Method of attaching hangers to building structure.
 - 3. Size and location of initial access modules for acoustical tile.
 - 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
 - 5. Duct access panels.
- E. Source quality-control reports.

PART 2 - PRODUCTS**2.1 CEILING DIFFUSERS, REGISTERS AND GRILLES**

- A. Rectangular and Square Ceiling Diffusers (A and B)

1. Manufacturers:
 - a. Carnes.
 - b. Hart & Cooley, Inc.; Hart & Cooley Div.
 - c. Krueger.
 - d. METALAIRE, Inc.; Metal Industries Inc.
 - e. Price Industries.
 - f. Titus.
 - g. Tuttle & Bailey.
 2. Material: Aluminum.
 3. Finish: Baked enamel, white
 4. Face Size: 24 by 24 inches (600 by 600 mm)
 5. Face Style: Three cone
 6. Mounting: T-bar
 7. Pattern: Adjustable.
 8. Dampers: Radial opposed blade Butterfly Combination damper and grid.
 9. Duct Inlet: Round sizes indicated on drawings.
 10. Accessories:
 - a. ½" thick foil backed insulation for mounting in hard ceiling
 - b. Plaster ring.
- B. Eggcrate Diffuser (C and D):
1. Manufacturers:
 - a. Carnes.
 - b. Hart & Cooley, Inc.; Hart & Cooley Div.
 - c. Krueger.
 - d. METALAIRE, Inc.; Metal Industries Inc.
 - e. Price Industries.
 - f. Titus.
 - g. Tuttle & Bailey.
 2. Material: Steel backpan and pattern controllers, with aluminum face.
 3. Finish: Baked enamel, white
 4. Face Size: 12 by 12 inches (300 by 300 mm) or 24 by 24 inches (600 by 600 mm) Duct Inlet: Round
 5. Face Style: ½" x ½" x ½" eggcrate core.
 6. Mounting: T-bar
 7. Accessories:
 - a. Plaster ring for mounting in hard ceiling.
- C. Louver Face Diffuser :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carnes.
 - b. METALAIRE, Inc.

- c. Nailor Industries Inc.
 - d. Price Industries.
 - e. Titus.
- 2. Devices shall be specifically designed for variable-air-volume flows.
- 3. Material: Aluminum.
- 4. Finish: Baked enamel, color selected by Architect.
- 5. Dampers: Radial opposed blade.
- 6. Accessories:
 - a. Square to round neck adaptor.
 - b. Adjustable pattern vanes.
 - c. Throw reducing vanes.
 - d. Equalizing grid.
 - e. Plaster ring.
 - f. Safety chain.
 - g. Wire guard.
 - h. Sectorizing baffles.
 - i. Operating rod extension.

2.2 CEILING LINEAR SLOT OUTLETS

A. Linear Bar Diffuser:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carnes.
 - b. Krueger.
 - c. METALAIRE, Inc.
 - d. Nailor Industries Inc.
 - e. Price Industries.
 - f. Titus.
- 2. Devices shall be specifically designed for variable-air-volume flows.
- 3. Material: Aluminum.
- 4. Finish: Baked enamel, color selected by Architect.
- 5. One-Way Deflection Vanes: Extruded construction fixed louvers with removable core.
- 6. Damper Type: Adjustable opposed-blade assembly.

B. Linear Slot Diffuser:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carnes.
 - b. Krueger.
 - c. METALAIRE, Inc.
 - d. Nailor Industries Inc.
 - e. Price Industries.
 - f. Titus.
- 2. Devices shall be specifically designed for variable-air-volume flows.

3. Material - Shell: Aluminum.
4. Material - Pattern Controller and Tees: Aluminum.
5. Finish - Face and Shell: Baked enamel, black.
6. Number of Slots: Two.
7. Length: 48 inches (1200 mm).

2.3 SOURCE QUALITY CONTROL

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

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as 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 233713

SECTION 234200 - GAS DETECTION SYSTEM**PART 1 – GENERAL**

- A. Provide a complete installation of a toxic gas detection system including a main control panel, sensors and audible/visual alarm devices that can be linked to a Central Controller or a Building Automation System (BAS).
- B. The system shall include, but not be limited to, the following:
 - 1. Future expandability
 - 2. Display of toxic gas concentration
 - 3. Ability to modify alarm set points
 - 4. Automatic and manual fan start/stop
 - 6. Display of alarm status

PART 2 – PRODUCTS**2.1 DETECTORS**

- A. Transmitter will be powered by the control panel power supply rated at 24 Vac. Fully addressable gas transmitter must be capable of communicating digitally with controller through an RS-485 communication port. Gas transmitters must be capable of performing self-diagnostics every 8 hours by testing the sensing element inside the transmitter. Transmitters must be installed in a true daisy chain with an end of the line resistor on the last transmitter. The gas transmitter will incorporate gas specific electrochemical cell for toxic gas monitoring. Unit sensing cell must compensate for variations in relative humidity and temperature to maintain high levels of accuracy.
- B. When placed in a network configuration the transmitter will be capable of transmitting gas concentrations and space temperature through the controller. For local activation of fans or louvers (or other equipment) an on-board DPDT relay 5 A, 30 Vdc or 250 Vac (resistive load) will be activated at programmable set points (and programmable time delays) through the control panel. An LCD display will provide gas concentration readings.
- C. Transmitter will be capable of operating within relative humidity ranges of 5-95% and temperature ranges of -4° F to 104° F (-20° C to 40° C).
- D. Unit will be certified to ANSI/UL 61010-1 label and CAN/CSA-C22.2 No. 61010-1. Transmitter must be manufactured in an ISO 9001-2000 production environment.
- E. The transmitter shall have a plug-in capability for a field replaceable gas cartridge with a smart sensor capable of self-testing. The replaceable gas cartridge shall be factory calibrated and certified to the target gas ready for operation without the requirement for site calibration.
- F. For local activation of audible alarms, the transmitter shall have an on-board device able to generate an audible output of 85 dBA @ 10 ft. (3M).

Detector alarm levels are to be activated and the unit is to be installed in accordance with the following parameters:

TOXIC GASES	1st ALARM SET POINT (TLV-TWA)	2nd ALARM SET POINT (TLV-STEL)	MOUNTING HEIGHT	COVERAGE RADIUS
Carbon Monoxide (CO)	25 PPM	100 PPM	900mm - 1500 mm (3 ft -5ft) above finished floor	15 m (50 ft)
Nitrogen Dioxide (NO ₂)	0.72 PPM	2.0 PPM	300mm (1 ft) below ceiling	15 m (50 ft)

Local Building Codes recommendations take precedence over these parameters. Coverage can differ depending on application

2.2 (1) CONTROLLER 301C and VA301R8

- A. The control panel must be capable of communicating digitally with the networked transmitters and relay modules through three RS-485 Modbus communication buses. Each communication bus must be capable of accepting a combination of up to 32 addressable transmitters, relay modules, or annunciator panels at a maximum distance of 2,000 feet. The power supply shall be of either 24 Vac or 24 Vdc
- B. The controller will manage four internal DPDT relays at fully programmable alarm levels (and within programmable time delays) and be capable of activating multiple relay modules of eight relays each. The relay rating will be no lower than 5 A, 30 Vdc or 250 Vac (resistive load).
- C. The controller must include a self-test function that allows for the activation/deactivation of all the programmed outputs by simulating a continuous 5% increase/decrease value until the maximum/minimum value is reached.
- D. The controller must include a real-time clock that enables operation of the outputs for a specific timeframe.
- E. The controller must also include an energy saving feature that allows for output operation on alarms set at the max, min or average value of a specific group of transmitters. This feature must also allow for the activation of outputs upon a certain number of a specific group ($\frac{3}{4}$, $\frac{1}{2}$, $\frac{1}{3}$ and $\frac{1}{4}$) of transmitters reaching their alarm levels. A total of 128 groups can be assigned.
- F. The controller will be capable of communicating with an annunciator panel that can serve as a remote display panel in a secondary control room.
- G. The controller will indicate the exact concentration of gas, the gas detected, and the location of the sensor by sweeping through the network and displaying the detected levels at each point on a graphic LCD display.
- H. Provide one VA301R8 relay module and VA420I module to control variable frequency drive in accordance to CO levels.

- I. BACnet option
The controller must enable BACnet communication through its optional BACnet output using BACnet/IP protocol over twisted-pair Ethernet (10BaseT) wires.\

2.3 ACCESSORIES

- A. Power Transformer type T100VA, T200VA or T300VA
Transformer shall have an input voltage of 120 V AC and an output voltage of 24 V AC with a VA range of 50-300. Operating frequency shall be 60 Hz. Unit will provide insulation systems up to 130° C (50-1300 VA). Unit will operate at sound levels of less than 40 db. Transformers shall be of fused type.
- B. Relay Modules 301R8 (Optional)
Relay module will be powered by the control panel's power output or by power transformer rated at 24 Volts AC or DC (always respect minimum voltage requirements at device). Module must be capable of communicating digitally with the Vulcain controller through an RS-485/MODBUS communication port. Relay module will have eight relays rated at no lower than 5A, 30 Vdc or 250 Vac (resistive load). Honeywell Analytics model VA301R8

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Install hazardous gas monitoring equipment including sensors, audible alarms, control panels as shown on Contract Drawings, and as recommended by manufacturer of equipment, and as required by authorities having jurisdiction.
- B. Install conduit and wiring from sensors to control panel and to the fan starters/ HVAC control panel as recommended by manufacturer of equipment.

3.2 SEQUENCE OF OPERATION

- A. Using the 301C controller, parking garage levels shall be grouped into separate groups. Garage level one designated as zone one. Garage level two designated as zone two. And garage level three designated as zone three.
- B. If any CO or NO₂ sensors in zone one (or group of sensors as programmed in zone as indicated) detects first alarm levels, exhaust fan EF-1 and exhaust fan EF-3 shall operate at 33 percent of maximum capacity. Exhaust fans shall continue to operate at this speed until hazardous gas concentration levels are reduced to below set point alarm levels.
- C. If any CO or NO₂ sensors in zone two (or group of sensors as programmed in zone as indicated) detects first alarm levels, exhaust fan EF-1 and exhaust fan EF-3 shall operate at 66 percent of maximum capacity. Exhaust fans shall continue to operate at this speed until hazardous gas concentration levels are reduced to below set point alarm levels.
- D. If any CO or NO₂ sensors in zone three (or group of sensors as programmed in zone as indicated) detects first alarm levels, exhaust fan EF-1 and exhaust fan EF-3 shall operate at

100 percent capacity. Exhaust fans shall continue to operate at this speed until hazardous gas concentration levels are reduced to below set point alarm levels.

E. High Level Alarm

- F. If hazardous CO gas concentrations are not cleared after 30 minutes or if any sensor detects a Carbon Monoxide concentration of 100 PPM gas, High Alarm indicator lights on the main panel and audible alarms are activated, ventilation in all zones is activated by the controller. Audible Alarm to sound and contacts continue to operate the exhaust fans until hazardous gas concentration levels are reduced to below set point alarm levels.

G. High Level Alarm

- H. If hazardous CO and NO₂ gas concentrations are not cleared after 30 minutes or if any sensor detects a Carbon Monoxide concentration of 100 PPM gas or 2ppm of NO₂, High Alarm indicator lights on the main panel and audible alarms are activated, ventilation in all zones is activated by the controller. Audible Alarm to sound and contacts continue to operate the exhaust fans until hazardous gas concentration levels are reduced to below set point alarm levels.

3.3 COMMISSIONING (Optional)

- A. After installation, test and calibrate equipment to demonstrate operation of functions described above under sequence of operation by manufacturers certified service technician. Issue certificate of operational and installation compliance to facility operators.

END OF SECTION 234200

SECTION 236200 - CONDENSER UNITS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes 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.

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 01 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."
- D. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

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 03.
- 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 specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Compressor failure.
 - b. Condenser coil leak.
 - 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 CONDENSING UNITS, AIR COOLED 1 TO 5 TONS

- A. Manufacturers:
 - 1. Carrier Corporation; Carrier Air Conditioning Div.
 - 2. Lennox Industries Inc.
 - 3. Rheem Manufacturing Air Conditioning Div.
 - 4. Trane Co. (The); Worldwide Applied Systems Group.
 - 5. Weatherking Air Conditioning Div.
 - 6. York International Corp.
 - 7. Goodman Manufacturing Co., L.P.
- B. Description: Factory assembled and tested, consisting of compressor, condenser coil, fan, motors, refrigerant reservoir, and operating controls.
- C. Compressor: Scroll, hermetically sealed, with rubber vibration isolators.
- D. Condenser Coil: Seamless copper-tube, aluminum-fin coil; circuited for integral liquid subcooler, with removable drain pan and brass service valves with service ports.
- E. Condenser Fan: Direct-drive, aluminum propeller fan; with permanently lubricated, totally enclosed fan motor with thermal-overload protection.
- F. Accessories:
 - 1. Crankcase heater.

2. Cycle Protector: Automatic-reset timer to prevent rapid compressor cycling.
 3. Digital Thermostat to control condensing unit and evaporator fan.
 4. Evaporator Freeze Thermostat: Temperature-actuated switch that stops unit when evaporator reaches freezing temperature.
 5. Filter-dryer.
 6. High-Pressure Switch: Automatic-reset switch cycles compressor off on high refrigerant pressure.
 7. Liquid-line solenoid.
 8. Low Ambient Controller: Cycles condenser fan to permit operation down to 0 deg F with time-delay relay to bypass low-pressure switch.
 9. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure.
 10. PE mounting base to provide a permanent foundation.
 11. Precharged and insulated suction and liquid tubing.
 12. Thermostatic expansion valve.
 13. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off.
- G. Unit Casing: Galvanized steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Mount service valves, fittings, and gage ports on exterior of casing.

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. 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.
- B. Concrete Bases:
 1. Install dowel rods to connect concrete base to concrete slab. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of the base.
 2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 3. Install anchor bolts to elevations required for proper attachment to supported equipment.
 4. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
- C. Maintain manufacturer's recommended clearances for service and maintenance.

- 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 23 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 23 Section "Refrigerant Piping."

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 weathertight.
 - 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. Verify proper operation of condenser capacity control device.
- F. After startup and performance test, lubricate bearings.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units.

END OF SECTION 236200

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Samples for Initial Selection: For units with factory-applied color finishes.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.
- F. Warranty: Sample of special warranty.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-Up."

- C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts: One year(s) from date of Substantial Completion.
 - c. For Labor: One year(s) from date of Substantial Completion.

1.7 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: One set(s) for each air-handling unit.
 2. Fan Belts: One set(s) for each air-handling unit fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.
 2. Daikin
 3. LG
 4. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
 5. SANYO North America Corporation; SANYO Fisher Company.
 6. Trane; a business of American Standard companies.
 7. YORK; a Johnson Controls company.

2.2 INDOOR UNITS 5 TONS OR LESS

A. Concealed Evaporator-Fan Components:

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
4. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; with a two-position control valve.
5. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
6. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
7. Fan Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
8. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
9. Filters: Permanent, cleanable.
10. Condensate Drain Pans:
 - a. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - 1) Depth: A minimum of 2 inches (50 mm) deep.
 - b. Single-wall, stainless-steel sheet.
 - c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - 1) Minimum Connection Size: NPS 1.
 - d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
 - e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

B. Wall-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.

3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
4. Fan: Direct drive, centrifugal.
5. Fan Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - c. Enclosure Type: Totally enclosed, fan cooled.
 - d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 - e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
 - f. Mount unit-mounted disconnect switches on exterior of unit.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
7. Condensate Drain Pans:
 - a. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - 1) Depth: A minimum of 1 inch (25mm) deep.
 - b. Single-wall, stainless-steel sheet.
 - c. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
 - d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - 1) Minimum Connection Size: NPS 1.
 - e. Pan-Top Surface Coating: Asphaltic waterproofing compound.
8. Air Filtration Section:
 - a. General Requirements for Air Filtration Section:
 - 1) Comply with NFPA 90A.
 - 2) Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
 - 3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
 - b. Disposable Panel Filters:
 - 1) Factory-fabricated, viscous-coated, flat-panel type.
 - 2) Thickness: 1 inch (25 mm).
 - 3) Merv according to ASHRAE 52.2: 8.

- 4) Media: Interlaced glass fibers sprayed with nonflammable adhesive.
- 5) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

2.3 OUTDOOR UNITS 5 TONS OR LESS

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Scroll.
 - b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - c. Refrigerant Charge: R-410A.
 - d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 210/240.
3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).
7. Mounting Base: Polyethylene.

2.4 ACCESSORIES

- A. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
- B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
- C. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
 1. Compressor time delay.
 2. 24-hour time control of system stop and start.
 3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
 4. Fan-speed selection including auto setting.
- D. Automatic-reset timer to prevent rapid cycling of compressor.
- E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
- F. Drain Hose: For condensate.
- G. Additional Monitoring:

1. Monitor constant and variable motor loads.
2. Monitor variable-frequency-drive operation.
3. Monitor economizer cycle.
4. Monitor cooling load.
5. Monitor air distribution static pressure and ventilation air volumes.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install ground-mounted, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base that is 4 inches (100 mm) larger, on each side, than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.
- D. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
- E. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.
- F. Install seismic restraints.
- G. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of **1 inch**.
- H. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

END OF SECTION 238126

SECTION 238219 - FAN COIL UNITS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes fan-coil units and accessories.

1.3 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Warranty: Special warranty specified in 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.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.5 COORDINATION

- A. Coordinate layout and installation of fan-coil units and suspension system components with other construction within mechanical room, including light fixtures, plumbing equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate size and location of wall sleeves for outdoor-air intake (if applicable).

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 specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Compressor failure.
 - b. Condenser coil leak.
 - 2. Warranty Period: Five years from date of Substantial Completion.

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. Fan-Coil-Unit Filters: Furnish 2 spare filters for each filter installed.
 - 2. Fan Belts: Furnish 1 spare fan belt for each unit installed.

PART 2 - PRODUCTS

2.1 DUCTED FAN-COIL UNITS

- A. Available Manufacturers:
 - 1. Carrier Corporation.
 - 2. Engineered Air Ltd.
 - 3. Environmental Technologies, Inc.
 - 4. First Co.
 - 5. International Environmental Corporation.
 - 6. McQuay International.
 - 7. Trane.
 - 8. YORK International Corporation.
- B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.
- C. Coil Section Insulation: 1-inch thick foil-faced glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
 - 1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

- D. Drain Pans: Plastic or Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1-2007.
- E. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panels.
- F. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
- G. Pleated Cotton-Polyester Media.
- H. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and brazed joints at fittings. Comply with ARI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.
- I. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
- J. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
- K. Basis of Design First Co. requires side inlet return correction with filter access from front of unit. Bottom return not acceptable due to location of hot water and shared mechanical rooms.

2.2 THERMOSTATS

- A. Manufacturers:
 - 1. Erie Controls.
 - 2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
 - 3. Heat-Timer Corporation.
 - 4. Sauter Controls Corporation.
 - 5. tekmar Control Systems, Inc.
 - 6. Theben AG - Lumilite Control Technology, Inc.
- B. Electric, solid-state, microcomputer-based room thermostat with remote sensor.
 - 1. Automatic switching from heating to cooling.
 - 2. Preferential rate control to minimize overshoot and deviation from set point.
 - 3. Set up for two separate temperatures per day.
 - 4. Short-cycle protection.
 - 5. Programming based on weekday, Saturday, and Sunday.
 - 6. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
 - 7. Battery replacement without program loss.
 - 8. Thermostat display features include the following:
 - a. Time of day.
 - b. Actual room temperature.

- c. Programmed temperature.
 - d. Programmed time.
 - e. Duration of timed override.
 - f. Day of week.
 - g. System mode indications include "heating," "off," "fan auto," and "fan on."
- g. Remote sensor features include:
 - a. Room temperature digital display.
 - b. Warmer/cooler buttons permitting 2° adjustment below/above setpoint.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- A. Install fan-coil units level and plumb.
- B. Install fan-coil units to comply with NFPA 90A.
- C. Verify locations of thermostats and other exposed control sensors with Drawings and room details before installation.
- D. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Install piping adjacent to machine to allow service and maintenance.
 - 2. Connect condensate drain to indirect waste.
 - a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

- B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan-coil units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238219

SECTION 260500 – GENERAL PROVISIONS**PART 1 - GENERAL****1.1 GENERAL CONDITIONS:**

- A. The accompanying General Conditions shall apply to and form a part of this Specification.

1.2 GENERAL REQUIREMENTS:

- A. Carefully examine General Conditions, other specification sections, and other drawings (in addition to DIVISION 26), in order to be fully acquainted with their effect on electrical work.
- B. Do all work in compliance with the latest adopted edition of the NEC, Ordinance 68831, NFPA 70 (NEC) and NFPA 101 (Life Safety Code), Fire code NFPC -1999, 2017 Florida Building Code, Americans with Disabilities Act (ADA) ANSI A117.1 and the Federal Fair Housing Act (42 U.S.C. 3601) and the regulations of the local utility telephone, cable television and power utility companies. Obtain and pay for any and all required permits, inspections, certificates of inspections and approval, and the like, and deliver such certificates to the Engineer.
- C. Obtain and pay for any and all required permits, inspections, certificates of inspections and approval, and the like, and deliver such certificates to the Engineer. Contractor is required to coordinate and schedule all utility work per the project schedule including but not limited to Power, Television and Telephone local utilities. Contractor shall pre-coordinate and confirm all utility incoming telephone, cable television and Ameren power utility infrastructure service connection points, housekeeping pads, conduit requirements, grounding requirements, and demarcation points of service prior to bidding and prior to any and all installations of conduits.
- D. Cooperate and coordinate with other trades and contractors at job. This includes project sub-contractors supplied and contracted directly to the owner including but not limited to Music, Audio/Visual Data/Communications/Security, CATV and CCTV. Perform work in such manner and at such times as not to delay work of other trades. Complete all work as soon as the condition of the structure and installations of equipment will permit. Contractor shall repair, correct, patch, paint, in a satisfactory manner and by the proper trade and craft, any work damaged by electrical workmen.
- E. The Contractor shall furnish, perform, or otherwise provide all labor (including, but not limited to, all planning, purchasing, painting, transporting, rigging, hoisting, storing, installing, testing, chasing, channeling, cutting, trenching, excavating and backfilling), coordination, field verification, equipment installation, support, and safety, supplies, and materials necessary for the correct installation of complete and functional electrical systems (as described or implied by these specifications and the applicable drawings).

1.3 DRAWINGS:

- A. Indicate only diagrammatically the extent, general character, and approximate location of work. Where work is indicated, but with minor details omitted, furnish and install it complete and so as to perform its intended functions. For building details and mechanical equipment, follow Architectural, Civil, Structural, and all Mechanical drawings and fit electrical work thereto as required to maintain code required clearance.
- B. All drawings and specifications on the project are complementary, each to all other sets, and they shall be used in combination for the execution of this work. DIVISION 26 (Electrical) work shown or implied on any one set of drawings, including all Architectural, Civil, Structural, Kitchen equipment, Smoke removal systems, Landscape, Audio/Visual, Music, Data/ Communications, Swimming Pool, Mechanical, Plumbing, Fire Alarm and Fire Protection

drawings for general work and equipment, and DIVISION 26 work called for under any section of the project specifications. All of this work shall be

- C. considered as included in this project work scope unless specifically excluded. This shall include roughing-in for all electrical connections and equipment as called for or inferred. The Contractor shall check all drawings and specifications

including but not limited to Architectural, Civil, Structural, Swimming Pool, Kitchen equipment, Landscape, Audio/Visual, Music, Data/ Communications, Show Systems, Mechanical, Plumbing and Fire Protection systems for the entire project and shall be responsible for the execution of all required of inferred DIVISION 26 work.

- D. Take finish dimensions at the job preference to scale dimensions. Where specific details and dimensions for DIVISION 26 work are not shown on the drawings, the Contractor shall take measurements and make layouts as required for the proper installation of the work and coordination with all drawings and coordination with all other work on the project. In case of any discrepancies between the drawings and the specifications that have not been clarified by addendum prior to bidding, it shall be assumed by the signing of the contract that the higher cost (if any difference in costs) is included in the contract price, and the Contractor shall perform the work in accordance with the drawings, specifications, **AS REQUIRED AND PER ALL APPLICABLE CODES** and as determined and approved by the OAR. No additional costs shall be allowed to the base contract price.
- E. Except as above noted, make no changes in or deviations from the work as shown or specified unless approved by the Owners Authorized Representative (OAR).
- F. The Contractor shall carefully check the drawings and specifications of all other trades including Smoke Control, Fire Alarm and Fire Protection and divisions before installing any of his work. He shall in all cases consider the work and clearances required of all other trades, and shall coordinate his work with them so that the best arrangements of all equipment, piping, conduit, ducts, rough-in, etc., can be obtained.
- G. Locations designated for speaker and A/V devices, outlets, switches, devices, equipment, etc., are approximate and final locations shall be verified in the field per the requirements of the code and coordinated with all trade Contractors actual drawings. Contractor shall re-move, re-locate and add any and all outlets, switches, devices, equipment in any direction as directed by OAR and or as required by the code. Where instructions or notes are insufficient to convey the intent of the design, consult the OAR prior to bidding and installation.
- H. Obtain manufacturer's data on all equipment, the dimensions of which may affect electrical work. Use this data to coordinate proper service characteristics, entry locations, etc., and to ensure minimum clearances are maintained.
- I. Contractor shall be responsible for verifying and coordinating the locations of devices and equipment to be used and coordinating the final locations of electrical equipment with Architectural features, kitchen and bar features and millwork, sinks, benches, counters and shelving prior to bidding and installation. All discrepancies shall be brought to the attention of the Owner prior to bidding.
- J. Contractor is required to coordinate all conduit penetrations through all concrete slabs to insure final structural integrity. Shop drawings for all communications and power conduit vertical and horizontal risers and routes shall be submitted to the structural Engineer for approval prior to construction.
- K. Locations designated for outlets, switches, devices, equipment, and electrical connections etc. are approximate and final locations shall be verified in the field. Contractor shall include the cost of locating all electrical devices, fixtures and electrical connections up to 10'-00" in any direction as directed by Owner or owners' representative and as

required per the Code. Where instructions or notes are insufficient to convey the intent of the design, consult the Owner prior to bidding and installation

1.4 QUALIFICATIONS OF CONTRACTOR:

- A. DIVISION 26 Contractor shall have had experience of at least the same size and scope as this project, on at least five other projects within the last five years in order to be qualified to bid this project.
- B. Workmen shall be experienced in their respective trade. Workmanship of installed work shall be first class and will be so judged by the Engineer and OAR. Substandard work shall be removed and replaced to the satisfaction of the OAR and Engineer.

1.5 SITE VISIT:

- A. The Contractor shall visit the site of this contract prior to bidding and shall thoroughly familiarize himself with all existing field conditions and the proposed work as described or implied by the contract documents. During the course of his site visit, the Contractor shall verify every aspect of the proposed work and the existing field conditions in the areas of construction which might affect his work. The Contractor shall receive no compensation or reimbursement for additional expenses he incurs due to his failure or neglect to make a thorough investigation of all of the contract documents, the existing site conditions, and the existing facilities prior to bidding.

1.6 WARRANTY:

- A. Contractor shall and does hereby warrant all materials and equipment furnished under this section of the specifications to be free from defects and to function or operate satisfactorily for one year after final acceptance of the work, and that any items not meeting this requirement will be made good by him without cost to Owner, provided such defects or failures are not due to abuse, neglect, or lack of reasonable and ordinary maintenance.

PART 2 - PRODUCTS

2.1 APPROVED MATERIALS AND DEVICES:

- A. Where not otherwise specified, provide only new, standard first-grade materials throughout, conforming to standards established by Underwriters' Inc., and so marked and labeled, together with manufacturer's brand or trademark.

PART 3 - EXECUTION

3.1 WORKMANSHIP:

- A. Perform and do all work in compliance with latest adopted edition of the Florida Building code, NFPA 70 (NEC), NFPA 101 Life Safety Code, Fair Housing codes and all local City and Florida Building Code as well as County and local codes and ordinances.
- B. All work shall be executed in a workmanship manner and shall present a neat mechanical appearance upon completion.
- C. Care shall be exercised that all electrical and Division 26 items are plumb, straight, level.

- D. Care shall be exercised so that Code clearance is provided for all panel-boards, disconnects, controls, equipment, etc. as required by code. It is the Contractors responsibility to provide for all required code required working clearance.
- E. Balance load as equally as practicable on all feeders, branch circuits and panel buses.
- F. The DIVISION 26 trades shall cooperate and confer with all other trades on the project, as to locations and requirements of their materials and equipment before erecting the work so as to avoid interference and delay in progress of construction. In instances where interference may develop, the Contractor shall relocate his work as approved by the Engineer, to depart from such interferences at no additions to the contract price. Where it is necessary to make adjustments in the locations or routing of conduits, wire ways, or other installations (from that shown on the drawings) to clear obstructions or other installed work, the Contractor shall be responsible for making these adjustments as a part of the contract work.
- G. The Contractor shall review the Contract Documents of ALL trades and shall coordinate work with all other trades as required to avoid installation and connection conflicts and interferences. All work shall be preplanned. Any conflicts or interferences which cannot be resolved shall be referred to the Engineer prior to installation of the equipment. A failure to obtain assistance from the Engineer prior to installation in order to correct a deficiency shall mean that the Contractor shall correct the deficiency at no additional cost to the Owner.
- H. The Contractor shall keep the construction site clean of all waste materials and rubbish caused by his work or employees. Upon completion of the work and at times during progress of the work when requested by the Engineer, the Contractor shall remove all surplus materials, rubbish, and debris resulting from the operation, and shall leave the entire building and involved portions of the site, insofar as the work of the contract is concerned, in a neat, clean, and acceptable condition as approved by the Engineer. Equipment, lighting fixtures, materials and accessories shall be thoroughly cleaned of cement, plaster, and other materials.
- I. The Contractor shall provide adequate protection wherever work is to be performed in finished/occupied spaces, to prevent damage to adjacent areas, equipment, or furnishings; to prevent power outages, to prevent accidental injury to building occupants and the public; to prevent the spreading of dust, dirt, debris, and moisture from the area where work is being performed; and to prevent dust, dirt, debris, and moisture from getting on or in the building occupant's furnishings or equipment.
- J. The Contractor shall repair, at no cost to the Owner, any damage done by himself or his employees. He shall also be responsible for all cutting and patching as required to properly install all work. This shall also include the patching of existing roadways (paved or improved), parking areas, sidewalks, walls, stairs, mechanical work, curbs, gutters, etc., cut to install work provided by the Contractor. Patch work shall comply with the applicable sections of these specifications and shall match the existing finishes.

3.2 ACCEPTANCE TESTING:

- A. Upon completion of work, the entire wiring system shall be tested, and shall be shown to be in proper working condition in accordance with intent of specifications and drawings. It shall be the responsibility of the Contractor to have all systems ready for operation and to have an electrician available to operate same in accordance with and under the supervision of the inspection representative of the Engineer. The Contractor shall be available to assist in removal of panel fronts, etc., to permit inspection as required.

3.3 AS-BUILT DRAWINGS:

- A. In accordance with DIVISION 1 and the Conditions of the Contract, the Contractor shall provide and keep up to date a complete record set of construction "As-Built" blue-line prints which shall be corrected daily, and shall show every change from the original contract drawings, including addenda and change orders in accordance with General Requirements and Special Conditions. This set of prints shall be kept on the job site, and shall be used only as a record set. Upon acceptance the Contractor shall convert the Blue Line drawings annotated onto the final record documents in electronic AutoCAD drawing media.
- All costs for the annotation of the final record documents shall be by this contractor.
- The presentation must match the previous drawing media exactly i.e. AutoCAD, Revit etc...
- This shall not be construed as authorization for the Contractors to make changes in the layout without definite instruction in each case.

END OF SECTION

SECTION 260501 - ELECTRICAL SCOPE**PART 1 - GENERAL****1.1 SCOPE:****A. Work Required:**

1. Furnishing and installation of electric power systems, and auxiliary systems as shown or herein specified.
2. Furnishing and installation of all electrical items shown on drawings or herein specified, unless shown or specified otherwise.
3. Furnishing and installation of disconnect switches and motor starters for motors and equipment unless equipment is equipped integral with the equipment or specified under another division.
4. Connection of all equipment requiring electrical connection, mentioned in this division or shown on drawings, whether furnished by Division 26 or under other divisions, or furnished by Owner.
5. Furnishing and installation of outlet boxes, conduit raceways, terminal boards, terminal cabinets, power, and grounding for a complete telephone and data wiring distribution system. (Telephone/Data, wiring, and data hardware and vertical wiring back bone wiring and software not included.)
6. Furnishing and installation of emergency and exit lighting systems.
7. Provide a complete standby generator system with Automatic transfer switch
8. Furnishing and installation of building grounding systems.
9. Furnishing and installation of television raceway and junction boxes.
10. Furnishing and installation of security system raceway and junction boxes.
11. Receive and install Owner provided equipment and devices.
12. Provide complete exterior and interior lighting system including control systems.
13. Furnish and install a complete fire alarm system with integration and connection with the building life safety systems.
14. The Contractor shall be fully responsible for contacting the offices of all local and/or state authorities having jurisdiction over this project in order to schedule all required inspections and obtain all necessary permits, etc. The Contractor shall notify the Architect/Engineer of all scheduled inspections at least two weeks in advance of the scheduled date.

15. The Contractor shall obtain and pay for any and all required permits, inspections, certificates of inspections and approval. He shall also pay for all connection charges or "aids to construction" charges assessed by the local utilities. These costs shall all be included in his bid price.
16. The Contractor shall obtain all necessary certificates issued by the authorities having jurisdiction over the work. The inspection certificates shall be received by the Architect/Engineer before work will be approved for final payment.
17. The Contractor shall replace any defective materials, equipment, or workmanship without cost to the Owner within the stipulated guaranteed period.
18. The Contractor is responsible for coordinating and programming the work of all trades and the responsibility of having their crews and materials available at the proper time.
19. The work shall include revisions, modifications, demolition, disposal and rework of the existing facility and systems as required for installation of new work, and for connections between existing work and new work where required. The work shall also include the completion of electrical power and control circuits for devices and equipment that are to remain in service, if the circuits are broken by demolition work, or by the removal or cutting of existing building construction, existing devices or equipment. Existing conduit wiring shall be rerouted and reconnected where necessary.
20. Each bidder shall inspect the site as required for knowledge of existing conditions prior to bidding and failure to obtain such knowledge shall not relieve the successful bidder of the responsibility to meet existing conditions in performing the work under this contract.
21. Where new work cannot be installed without changes in existing facility or systems or where it is indicated on drawings to rework an existing installation, this contract shall include alterations to existing work as required to install new work. Additions to the contract cost will not be allowed because of this Contractor's failure to inspect existing conditions at the site of the work.
22. Existing conditions indicated on the drawings are taken from the best information available on previous contract drawings and from visual site inspection and are not to be construed as "As-Built" conditions, but are to indicate the intent of this work. It shall be the responsibility of the Contractor to verify all existing conditions at the project site prior to bidding and to perform the work as required to meet the existing conditions and the intent of this work indicated.
23. Existing material and equipment removed from existing construction and not shown or required to be reused shall become the property of the Contractor, unless otherwise noted or indicated and shall be promptly and legally removed from the site.
24. Any existing material or equipment which is to be reused or left in place and is damaged by performance of work under this contract shall be repaired or shall be replaced with new equipment and material at the expense of the Contractor, to the satisfaction of the Architect/Engineer and/or Owner's authorized representative.

25. It shall be the responsibility of the Division 26 Contractor to have all systems ready for operation and to have an electrician available for all inspections. The Contractor shall provide personnel to assist in removal of panel fronts, etc. to permit inspection as required.

PART 2 - PRODUCTS

2.1 SHOP DRAWINGS:

- A. Submit to the Architect/Engineer promptly after award of contract and prior to purchasing, six copies of manufacturer's shop drawings in accordance with DIVISION 1, SECTION 013000 - SUBMITTALS for the following items. All shop drawings of a specific item or system shall be made in one submittal and within ten days after award of contract.
- | | |
|--|--|
| 1. Panelboards | 8. Circuit Breakers |
| 2. Lighting Fixtures | 9. Load Centers |
| 3. Fire Alarm Systems | 10. Lighting Relay controls |
| 4. Wiring Devices | 11. Meter Centers |
| 5. Disconnect Switches | 12. Occupancy Switches |
| 6. Transient Voltage Surge Suppression | 13. Standby Generator system |
| 7. Switchboards | 14. Automatic transfer switch |
| | 15. Transient Voltage Surge suppressor |
- B. Provide certification that all other items are as specified.
- C. The Architect/Engineer will return the shop drawing submittals with a stamp indicating approval, approved as noted, etc.
- D. Provide copies of all approved shop drawings with "As-Built" drawings.

2.2 SUBMITTALS:

- A. All materials and equipment shall be submitted by manufacturer, trade name and model number. The submittal shall include copies of applicable brochure or catalog material for all items. The Contractor shall not assume that applicable catalogs are available in the Architect/Engineer's office. Maintenance and operating manuals are not suitable submittal material. Each sheet of printed submittal material shall be clearly marked (using arrows, underlining, or circling) to show the particular sizes, types, model numbers, rating, capacities, and options actually being proposed. Non-applicable material shall be crossed out. All specified features must be specifically noted on the submittal. See DIVISION 1 for requirements concerning shop drawing and brochure submittals.

PART 3 – EXECUTION

3.1 MOTORS, STARTERS AND CONTROLS:

- A. Unless otherwise specified or shown, all motors will be furnished and installed under other divisions of these specifications. All power wiring to motor starters and motors shall be under DIVISION 26.
- B. Unless otherwise specified or shown, all motor starters will be furnished, installed and wired in conduit under this DIVISION 26 of this specification. All 120 volt power wiring for energy management systems, controls, smoke dampers, and temperature control power source shall be furnished and installed under DIVISION 26 to a point (junction box or control cabinet as indicated) for connection by Control Installer. Verify requirements from Control Installer prior to bidding. Contractor shall install and connect all Variable Frequency drive equipment for Air Handler HVAC Equipment.

3.2 ADJUSTING, ALIGNING, AND TESTING:

- A. All equipment furnished under this division shall be adjusted and tested by the Contractor. Motors and other equipment furnished by others, to which electrical connections are made under this division, shall be checked for short circuits and open circuits before energizing. Motors shall be checked for proper phasing and rotation. The thermal overload protection devices shall be checked in all motor starters, equipment, and all protection device size, motor nameplate full load amperage, and voltage rating for protection of the motor shall be listed (include equipment designation, rating of heater, motor nameplate horsepower, full load amps and voltage) and four copies of list shall be submitted to the Architect/Engineer.
- B. Mechanism of all electrical equipment shall be checked, adjusted, and tested for proper operation. Protective devices and parts shall be checked and tested for specified and required application and adjusted as required. Adjustable parts of all lighting fixtures and electrical equipment shall be checked, tested, and adjusted as required to produce the intended performance.
- C. Completed wiring systems shall be free from short circuits and after completion, perform tests for insulation resistance in accordance with the requirements of the National Electrical Code. All wiring systems shall be completely and totally "safed" during construction. Only qualified personnel shall handle electrical systems.

3.3 ELECTRICAL CIRCUITRY FOR EQUIPMENT:

- A. The electrical circuits, components, and controls for all equipment are selected and sized, based on the equipment specified. If substitutions and/or equivalent equipment are furnished, it shall be the responsibility of all parties concerned, involved in, and furnishing the substitute and/or equivalent equipment to verify and compare the electrical characteristics and requirements of that furnished to that specified and/or shown. If greater capacity or more materials or labor is required for the rough-in, circuitry or connections than for the item specified and provided for, then it shall be the responsibility of the parties involved in providing the substitute and/or equivalent items of equipment to provide all compensation for additional charges made for the proper rough-in, circuitry and connections for the equipment furnished. No additional charges above the Base Bid shall be allowed for such revisions.

- B. Before rough-in of circuitry or connecting to equipment, furnished under this division, any other division, or by the Owner, the Contractor shall verify and coordinate the final electrical characteristics and requirements of the equipment being furnished and for that specified and shown on the drawings and provide for proper electrical rough-in and connection.
- C. It shall be the Contractor's responsibility to verify exact requirements for rough-in and connections of equipment furnished by others prior to installation. Extras will not be allowed for failure to verify rough-in and connection requirements before, after, and during installation.

3.4 EXCAVATION, CUTTING PATCHING:

- A. All excavation and trenching shall conform to the requirements of the Missouri Trench and Safety Act.
- B. Excavation for Underground Electrical Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10'; plus a sufficient distance to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.
- C. Excavate, by hand, areas within drip-line of large trees. Protect the root system from damage and dry-out. Maintain moist conditions for root system and cover exposed roots with burlap. Paint root cuts of 1" in diameter and larger with emulsified asphalt tree paint.
- D. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.
- E. Trenching: Excavate trenches for electrical installations as follows:
 - 1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6" to 9" clearance on both sides of raceways and equipment.
 - 2. Excavate trenches to depth indicated or required.
 - 3. Limit the length of open trench to that in which installations can be made and the trench backfilled within the same day.
 - 4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceways and equipment. Provide a minimum of 6" of stone or gravel cushion between rock bearing surface and electrical installations.
 - 5. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35°F.
- F. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below.
 - 1. Under walks and pavements, use a combination of subbase materials and excavated or borrowed materials.
 - 2. Under building slabs, use drainage fill materials.
 - 3. Under piping and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.

4. For raceways less than 30" below surface of roadways, provide 4"-thick concrete base slab support. After installation of raceways, provide a 4"-thick concrete encasement (sides and top) prior to backfilling and placement of roadway subbase.
 5. Other areas use excavated or borrowed materials.
- G. Backfill excavations as promptly as work permits, but not until completion of the following:
1. Inspection, testing, approval, and locations of underground utilities have been recorded.
 2. Removal of concrete formwork.
 3. Removal of shoring and bracing, and backfilling of voids.
 4. Removal of trash and debris.
- H. For all such work employ competent workmen, and finish up in neat and workmanlike manner, equal in quality and appearance to adjacent work.

3.5 SUPPORTS AND SLEEVES:

- A. The Contractor shall provide all pre-layout the location of all penetrations and inserts for the routing and support of DIVISION 26 equipment to be placed in concrete or through concrete slabs as construction progresses. This shall include penetrations for conduits, and busway. He shall provide all miscellaneous hanging and supporting hardware. All electrical work is to be concealed in or built into general construction shall be placed as construction progresses. Failure of the Contractor to coordinate work with other trades and the project construction progress shall make him responsible for all cost of cutting and patching, as required to install work. No structural member, masonry construction or finished work shall be cut or altered without prior written approval by the Architect/Engineer. Contractor shall fire rate all vertical and horizontal penetrations through all fire rated slabs or walls per the intended UL listed rating.
- B. The Contractor shall supply and set into place all wall sleeves for conduits and ceiling inserts for hangers in areas of new construction as building construction progresses. Install equipment noted to be concealed in walls before walls are constructed in order that walls may be constructed around conduits, enclosures, etc. Contractor shall pre-plan and coordinate and provide all core holes and drilling as required to install all branch and feeder wiring and all Busways. Coordinate all core drilling with the Structural Engineer prior to drilling any members or floors. Contractor is required to lay out too scale and coordinate all conduit and busway penetrations through all concrete slabs to insure final structural integrity. Shop drawings for all communications and power conduit vertical and horizontal risers and routes shall be submitted to the structural Engineer for approval prior to construction.

3.6 PROTECTION:

- A. Metallic materials shall be protected against corrosion. Equipment enclosures shall be given rust-inhibiting treatment and standard finish by manufacturer. Aluminum shall not be used on contact with earth, and, where connected to dissimilar metal, shall be protected by suitable fittings and treatment. All ferrous metals such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous parts, not of stainless steel or nonferrous materials, shall be hot-dipped galvanized.
- B. The Contractor shall fully protect all finish parts of the materials and equipment against damage from whatever cause during the progress of the work until final completion. All materials and equipment in storage and during

construction shall be covered in such a manner that no finished surfaces will be damaged or marred, and all moving parts shall be kept perfectly clean and dry.

- C. All conduits stubbed out for future use shall have a pull wire installed; a plastic cap installed and be identified as to the conduit origin.
- D. No underground junction boxes shall be installed for any system type wiring, except for device floor boxes and pullboxes, and secondary power pull boxes.

3.7 CLEARANCES:

- A. The Contractor shall install all equipment so that all code-required and manufacturer-recommended servicing clearances are maintained. He shall be responsible for the proper arrangement and installation of all equipment within any designated space.
- B. Should the Contractor determine that a departure from the contract drawings is necessary, he shall submit to the Architect/Engineer for approval, detailed drawings of his proposed changes with his written reasons for the changes. No changes shall be implemented without the issuance of the required bulletin drawings, clarifications, and/or change orders.

3.8 CUTTING AND PATCHING:

- A. The responsibility for any cutting of construction which is required for the installation of DIVISION 26 work, shall be by the Contractor. The Contractor shall coordinate with all other Trades and the Owner before any cutting and obtain approval from the Architect/Engineer prior to any cutting. All patching and finishing shall be by the Contractor.
- B. Cutting shall be done with extreme care and in such a manner that the strength of the structure will not be endangered. Wherever possible, openings in concrete or masonry construction shall be by concrete saw or rotary core drill. Openings in any construction shall be cut the minimum size required for the installation of the work. Adequate protection shall be provided to prevent damage to adjacent areas and to prevent dust from spreading to adjacent areas.
- C. Where openings or holes are cut in construction and the cutting breaks electrical circuitry or control circuitry conduit and wiring, then it shall be the responsibility of the Contractor to reroute the circuitry conduit and rewiring and to complete the circuitry as required and as approved by the Architect/Engineer. Temporary completion shall be provided where necessary before the permanent rerouting and completion work is finished.
- D. Before any cutting, patching, or finishing work is started, dust and moisture protection shall first be installed as required and as specified in these specifications.
- E. Openings cut in floor shall be cut by core drilling where possible. After work is installed through any opening in floor, the opening around the work shall be patched and sealed watertight and epoxy or silicone based, non-cracking elastomeric sealant and fire rated, as required.

3.9 RATED ASSEMBLY PENETRATIONS:

- A. Any penetrations of fire or smoke rated assemblies made by this Contractor or by any other contractor in new vertical or horizontal construction shall be fire rated and sealed and protected by this Contractor in order to maintain the established UL tested and accepted fire rating of the opening with methods as approved by the authority having jurisdiction UL and per the project specifications. Contractor shall provide the required Fire Alarm and 120v power connections to all devices weather indicated on the drawings or not.

3.10 PAINTING:

- A. Finish field painting is not included in this division. * (See SECTION, PAINTING.) All factory painted equipment shall be protected during construction.

3.11 IDENTIFICATION:

- A. Identification nameplates shall be laminated plastic, secured to equipment with two screws.
- B. Each panelboard shall be equipped with a permanent color coded plastic nameplate with 1/2" minimum letters, securely fastened to the device.
- C. Each individually mounted circuit breaker, switchboard, panelboard, switch, motor starter, relay cabinet, lighting contactor, dimming or relay panel, and/or any other control or protective device including equipment disconnect switches shall be equipped with a color coded permanent plastic nameplate with 1/2" minimum letters.
- D. All Panel boards shall have correct and typewritten directories. All circuits to be identified by devices served and room numbers (i.e., lighting Room 216). Handwritten directories will not be allowed or accepted.
- E. Each junction box, cabinet or wireway larger than 6" x 6" shall be equipped with a permanent color coded plastic nameplate with 1/2" minimum letters indicating the system enclosed.
- F. All Systems junction boxes and conduit shall be color coded inside and outside of the box prior to the installation of conductors per the following:
 - 1. Grounding System: Green
 - 2. Fire Alarm System Red
 - 3. Data/Communications Blue
- G. Entire box inside and out, including cover, shall be painted prior to installing conductors.

3.12 STORAGE OF MATERIALS:

- A. Store all materials to prevent damage from rust, corrosion, physical injury, etc.
- B. Keep site clean of accumulation of cartons, trash, debris, etc.

3.13 "AS-BUILT" DRAWINGS:

- A. In accordance with DIVISION 1 and the Conditions of the Contract, the Contractor shall provide and keep up to date a complete record set of construction "As-Built" blue-line prints which shall be corrected daily, and shall show every change from the original contract drawings, including addenda and change orders in accordance with General Requirements and Special Conditions. This set of prints shall be kept on the job site, and shall be used only as a record set. This shall not be construed as authorization for the Contractors to make changes in the layout without definite instruction in each case.

3.14 OPERATIONS AND MAINTENANCE INSTRUCTION:

- A. At the completion of the job, the Contractor shall turn over to the Architect/Engineer one set of marked "As-Built" drawings, plus three sets of all equipment catalog and maintenance data and three sets of shop drawings on all equipment. See paragraph "SHOP DRAWINGS" in this section. Contractor shall explain and demonstrate all systems to Owner's Representative.

3.15 ACCESS PANELS:

- A. Access panels for DIVISION 26 equipment, devices, junction boxes, etc., shall be provided by this Contractor where building finishes do not allow access. This Contractor shall furnish and have installed appropriate access panels and, patch and paint all surfaces. This Contractor shall coordinate panel locations with the installing Contractor.

END OF SECTION

SECTION 260502 - BASIC MATERIALS AND METHODS**PART 1 - GENERAL****1.1 SCOPE:**

- A. This section outlines the intent of the plans and specifications of DIVISION 26 with regard to Basic Materials and Methods.

PART 2 - PRODUCTS**2.1 MATERIAL FURNISHED AS SPECIFIED:**

- A. Material proposed to be furnished as specified shall be in strict accordance with the drawings and specifications of DIVISION 26 and of the requirements of WCI. Shop drawings shall be furnished as required by SECTION 26 05 01 - ELECTRICAL SCOPE. All material furnished is subject to the approval of the Architect/Engineer and his authority for approval is final.
- B. All electrical equipment shall be furnished with factory identification for the suitability of use and installation, either by a description marked on the equipment, permanently attached label, or printed description packed with the equipment, in accordance with Article 110 of the National Electrical Code (NEC). If a printed description is packaged with the equipment, this shall be bound in the Operation and Maintenance Manuals.
- C. All material and equipment shall be new; shall be of the best quality and design; shall be free from defects and imperfections and shall have markings, or a nameplate identifying the manufacturer and providing sufficient reference to establish quality, size, and capacity. As possible, all material and equipment of the same type shall be of the same manufacturer. Equipment shall function and perform efficiently and quietly at the required capacity without producing objectionable noise within the occupied areas of the building; if not, the Contractor shall remedy the condition or replace the equipment at no additional cost to the Owner.

2.2 MATERIAL SUBSTITUTIONS:

- A. No substitutions other than manufactures listed will be considered for this project.

PART 3 - EXECUTION**3.1 SAFETY:**

- A. Maximum consideration shall be given to job safety and only such methods as will reasonably ensure the safety of all persons shall be employed. The codes and regulations of OSHA shall be given strict compliance as well as such other codes, laws, and regulations as may be applicable.

3.2 TECHNIQUE:

- A. It is the intent of these plans and specifications to direct attention to the absolute necessity to use safe techniques and ones that provide quality installations in compliance with good practice and the plans and specifications of DIVISION 26.

3.3 PROTECTION:

- A. Every precaution shall be taken during handling, installation, connection, transporting, erection, and performing any work to prevent and eliminate dust, debris, and moisture from entering or being carried into spaces outside the work area and onto or into the finished spaces. Cutting, patching, finishing, painting, or any other construction work which will cause dirt or dust to be created shall be separated from finished spaces by temporary dustproof partitions or curtains sealed at top, bottom, and all around.

END OF SECTION

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS/CABLES

PART 1 - GENERAL

1.1 SCOPE:

- A. This section outlines the quality and type of conductors to be used in the various systems, locations and conditions.

PART 2 - PRODUCTS

WIRE AND CABLE 600 VOLT:

A. GENERAL:

1. Conductors shall have current carrying capacities as per NEC and with 600 volt insulation, #12 AWG average minimum for 20 amp circuits except for controls, and fixture wire. Conductors shall be copper. However, feeders sized larger than 100 amps may be compact aluminum. Contractor to provide equal or larger conductor sizing/rating than the specified copper conductors.

NOTE: Prior authorization from the Architect/Engineer if conductors are substituted to Compact Aluminum conductors rated above 100 amps. Conductors must have the equivalent or greater ampacity value than that of specified copper, shall physically fit below the connection lug and shall be submitted to the engineer for approval. All lugs shall be sized and rated for copper and aluminum conductors. Conductors shall be installed utilizing "no-lox" anti-oxidation compound and conductors shall be designated as "compact aluminum". All conductors, wire, and cable shall be installed in conduit unless otherwise noted.

NOTE: Non-metallic sheathed (Type NM) and S.E.R. type feeder cable may be utilized for residential apartment units only as approved by the authority having jurisdiction and if installed per the latest adopted edition of the National Electric Code and per the manufacturer's recommendations. Prior written authorization from the AHJ is mandatory and must be submitted with shop drawings prior to authorization for use.

B. GENERAL USE:

1. #12 and #10 shall be solid, type THWN/THHN insulation.

C. FEEDERS AND GENERAL USE:

1. #8 awg and larger, and any size to motors shall be stranded type THWN.

D. FIXTURE WIRE:

1. Fixture wire shall be type SF-2 except that type THHN or XHHW may be used in the channel of and flex to fluorescent fixtures. Wire size shall be #16 AWG for fixtures up to 300 watts, #14 AWG for fixtures over 300 watts up to 1,500 watts and as required for fixtures over 1,500 watts. Fixture wire shall extend only from the fixture to the first junction box and not over 6' in length.

E. CONTROL WIRE:

1. Control wire shall be minimum #12 AWG copper, type THHN-THWN. Full color range as indicated for individual systems. See other sections of the specifications for requirements.

F. MANUFACTURER:

1. Wire and cable shall be as manufactured by Southwire Corporation.

G. WIRE CONNECTIONS:

1. On wire larger than #10 shall be made with approved solderless connectors and covered with Scotch #33 electrical tape so that insulation is Owner approved equal to conductor insulation.
2. All connections and splices in exterior, handholes, pull/junction boxes, and underground locations shall be waterproof.

H. #10 AND SMALLER COPPER CONNECTIONS:

1. Shall be made with T & B Sta-Kon wire joints, PT series, complete with insulating caps and installed with WT161 Tool or WT2000 Tool, Ideal Super-Nuts (not wire nuts), Ideal Wing Nuts, or Buchanan Elec. Products B Cap or Series 2000 Pres-Sure connectors complete with nylon snap-on insulators and installed with C24 pressure tool.

2.2 METAL CLAD CABLE (MC)

- A. The use of Metal Clad Cable is acceptable in concealed locations as accepted by the NEC, the owner and all local jurisdictional codes.

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRE AND CABLE:

- A. No conductor shall be smaller than #12 except where so designated on the drawings or hereinafter specified.
- B. All conductors, wire, and cable shall be installed in conduit unless otherwise noted.
- C. Multi-wire lighting branches shall be used as indicated.
- D. All joints and splices in wire shall be made with approved solderless connectors, and covered so that insulation is Owner approved equal to conductor insulation. Splices shall not be permitted in control, security, fire alarm, television or communications systems, or where otherwise noted. Splicing of wire or cables will not be allowed below grade, including within boxes below grade.

- E. No splices shall be pulled or installed into conduit.
- F. Both conductors and conduits shall be continuous from outlet to outlet.
- G. No conductor shall be pulled until conduit is cleaned of all foreign matter.
- H. In installing the main electrical service, additional slack conductors shall be provided and terminated as required by electric utility for connection to utility equipment. Field coordinate with utility prior to installing conductors. Contractor shall provide all secondary connections to utility company transformer per utility company requirements. Provide all lugs, spade conductors, etc., per drawing requirements.
- I. In installing parallel conductors, it is mandatory that all conductors making up the feeder be exactly the same length, the same size and the same type of conductor with the same insulation. Further, each group of conductors making up a phase or neutral must be bonded at both ends in an approved manner.
- J. Conductor sizes indicated on circuit homeruns or in panelboard schedules shall be installed over the entire length of the circuit unless noted otherwise on the drawings.
- K. Conductors shall be continuous and unspliced where installed in conduit. Splices shall occur only within wiring troughs, wireways, junction boxes, outlet boxes, or equipment enclosures where sufficient additional room is provided for all splices.
- L. Provide isolated ground conductors per drawing requirements.

3.2 CIRCUITS AND BRANCH CIRCUITS:

- A. Outlets shall be connected to branch circuits as indicated on drawings. No more outlets than are indicated shall be connected to a circuit.

3.3 WIRE AND CABLE DESIGNATION AND COLOR CODING:

- A. Non-ferrous identifying tags or pressure sensitive labels shall be securely fastened to all cables, feeders, and power circuits in panels, starters, terminations of cables, etc. Tags or labels shall be stamped or printed to correspond with markings on drawings so that feeder or cable number and phase can be readily identified.
- B. Each branch circuit and feeder conductor shall be color coded. For all conductor sizes the entire insulation shall be of the color as indicated below. Color code shall be strictly adhered to. Phase tape is not permitted.

120/208 Volts	
Phase	Color
A	Black
B	Red

C	Blue
Neutral	White
Ground	Green

END OF SECTION

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SCOPE:

- A. This section deals with the grounding of service equipment, transformers, non-current carrying conductive surfaces of equipment, metal building, structures and other equipment.
- B. All grounding connections shall be installed in accordance with the National Electrical Code and all local codes and requirements. Such codes shall be considered minimum requirements and the installation of the grounding system shall insure freedom from dangerous shock exposure and shall provide a low impedance ground fault path to permit operation of overcurrent and ground fault protective devices.

PART 2 - PRODUCTS

2.1 CONDUCTORS:

- A. All service and equipment grounding conductors, and bonding jumpers shall be insulated copper, type THHN, or THWN, conductors (unless noted otherwise) and shall be sized in accordance with the applicable portions of Articles 250 of the National Electrical Code. All Grounding conductors shall have a total green color insulation. Phase tape is not permitted.

2.2 GROUND RODS:

- A. Ground rods shall be sectional 5/8" by 10', copperclad. All ground rods shall have a total 50'-0" length.

2.3 CONNECTIONS:

- A. The Connection of a grounding conductor to ground rods shall be by Exothermic Welding.
- B. Ground connections to building steel, equipment enclosures, equipment, and for all conductors size #3 AWG and larger shall be bolted using T & B hydraulic compression type lugs, except all connections below grade and to ground bars shall be exothermic weld type.
- C. Grounding conductor connections at conduit terminations shall be made by approved grounding bushings.

PART 3 - EXECUTION

3.1 MAIN SERVICE GROUNDING ELECTRODE SYSTEM:

- A. The main service grounding electrode system shall consist of the following items bonded together by the grounding electrode conductors in accordance with NEC Article 250.

1. The main underground cold water pipe, if metal, NEC 250
 2. Metal frame or structure of building where available, NEC 250
 3. Concrete encased electrode, NEC 250
 4. Fire Pump control system where Fire Pump is part of the project scope
 5. Roof top Lighting Protection System where required.
- B. Driven ground rods, spaced a minimum of 20' apart and connected parallel until resistance to ground does not exceed 5 ohms.
- C. Main electrical panel at each building shall be grounded as indicated above. In addition, a grounding conductor shall be installed with the feeders and bonded to the main service grounding electrode system.
- D. The neutral conductor shall be grounded at the service entrance main disconnect, and at each separately derived system only per NEC Article 250.

3.2 FEEDERS AND BRANCH CIRCUITS:

- A. All feeders and branch circuits shall have installed in the same raceway as the circuit conductors, an insulated copper grounding conductor sized in accordance with Table 250 of the National Electrical Code unless such a grounding conductor is shown to be larger on the plans or specified to be larger elsewhere in these specifications.

3.3 EXPOSED NON-CURRENT CARRYING CONDUCTIVE SURFACES:

- A. All exposed non/current carrying conductive surfaces of electrical equipment shall be grounded by a grounding conductor either run with the circuit conductors, and/or separate grounding conductors as shown.

3.4 OUTLET GROUNDING:

- A. No electrical system neutral shall be used for an equipment ground.
- B. All outlet boxes and junction boxes, lighting fixtures, convenience receptacles, switches, disconnects, etc. shall be grounded. The ground wire terminal of each convenience receptacle shall be connected to the grounding conductor. All motors, enclosures for electrical controls, all metal equipment supports for electrical controls and all similar items shall be connected to the grounding system.
- C. All receptacles shall be grounded by connection to the equipment grounding conductor run with the circuit conductors. isolated grounding conductors shall connect to the equipment device, equipment ground conductor shall connect to the device box.

3.5 SYSTEMS GROUNDING:

- A. A #4 insulated copper conductor installed in 3/4" concealed conduit shall be connected from the building grounding electrode system to each building mechanical EMS control cabinet, Fire Alarm Control Panel (FACP),

MDF and IDF cabinets and racks, telephone terminal boards, Lighting relay Panels, Dimming Panels, and security system cabinets. Terminate on an appropriately sized (8) terminal multi-conductor connection grounding lug located within cabinet or on terminal boards.

- B. Provide copper ground bus as indicated. All connections shall be Xothermic cadweld where accessible.

END OF SECTION

SECTION 260533 – RACEWAYS - METAL**PART 1- GENERAL****1.1 SCOPE:**

- A. This section deals with the materials to be used as metal raceways, connections, and supports.
- B. Minimum conduit size shall be 1/2" or unless otherwise noted.

PART 2 - PRODUCTS**2.1 CONDUIT - RIGID and E.M.T.:**

- A. Shall be galvanized outside and inside by hot dipping. E.M.T. shall be Electro-Galvanized. Conduits shall be as manufactured by Republic, Pittsburgh Standard, Wheatland, Triangle, Allied, or Youngstown.

2.2 COUPLINGS AND CONNECTORS RIGID AND I.M.C.:

- A. Shall be standard threaded type, galvanized outside and inside by hot dipping. Threadless and clamp type not acceptable. Shall be as manufactured by Raco, Efcor, or Appleton.

2.3 COUPLINGS AND CONNECTORS - E.M.T.:

- A. Shall be steel threaded compression type. All couplings and connectors shall be Efcor or Raco. Pressure indented type connectors or cast metal will not be approved for any location.
- B. Connectors shall have plastic insulated throat inserts.

2.4 CONNECTORS - RAIN-TIGHT:

- A. Shall be Meyers or Owner approved equal.

2.5 BUSHINGS:

- A. Rigid, shall be threaded, insulated, malleable iron O.Z. type "B" or Efcor type 55. Grounding bushings shall be O.Z. type "LG" or Efcor type 56.

2.6 WATER TIGHT FLEX CONNECTORS:

- A. Shall be Efcor, Raco, or Midwest Liquid Tite, with insulated throat.

2.7 CONDUIT CLAMPS AND SUPPORTS:

- A. Shall be as manufactured by Efcor, Raco, Steel City, or G.A. Tinnerman.

2.8 CONDUIT FITTINGS:

- A. Shall be manufactured by Pyle-National, Crouse-Hinds, Raco, Russell & Stoll, or Appleton.

PART 3 - EXECUTION

3.1 CONDUIT, TYPE OF INSTALLATION:

- A. Two inches and smaller may be used where concealed in ceiling or walls, where there is no danger of mechanical injury. E.M.T. may be used where exposed 4' above floor for conduits 2" or smaller, unless otherwise noted.
- B. Unless shown or specified otherwise, galvanized rigid conduit shall be used as follows: (a) in floor slab, (b) for exterior use or other areas exposed to moisture, (c) where danger of mechanical injury exists, (d) through floor slab, (e) where E.M.T. or nonmetallic conduit is not specifically permitted per these specifications or NEC standards, and (f) in parking garages up to 8" -00" aff.
- C. Liquid-tight flexible metal conduit shall be used for final connection to all motors, exterior HVAC units, transformers, all data equipment and all other rotating or vibrating equipment. Maximum length of 24".
- D. Conduit installed below building footings and thru exterior walls shall be galvanized rigid steel.
- E. Flexible metallic conduit raceways may be used to connect HVAC units located in interior mechanical areas. Minimum size ½" .

3.2 INSTALLATION OF CONDUIT, E.M.T., RIGID:

- A. Follow methods which are appropriate and approved for the location and conditions involved. Where not otherwise shown, specified, or approved in a particular case, run all wiring concealed.
- B. Where rigid, and aluminum conduits enter boxes they shall be secured in place by approved lock nuts each side and bushings.
- C. Where E.M.T. enters boxes they shall be secured in place with approved threaded compression type fittings.
- D. Conduit ends shall be carefully plugged during construction.
- E. Use of running threads is absolutely prohibited. Conduit shall be jointed with approved conduit couplings. All couplings on I.M.C. and rigid conduit shall be threaded.
- F. Before installing raceways for motors and fixed appliances, check locations of motor and/or appliance connections and locate and arrange raceways appropriately. Provide liquid tight flexible conduit connections to all motors, kitchen equipment, dry type transformers, and/or any equipment which has moving or vibrating parts. Liquid tight flexible metal conduit shall generally not exceed 24" in length.

- G. Exposed conduit runs shall be parallel and/or at right angles to building walls and/or partitions.
- H. Where conduit crosses a structural expansion joint an approved conduit expansion fitting will be installed.
- I. Fasten conduit securely in place by means of approved conduit clamps, hangers, supports, and fastenings. Arrangements and methods of fastening all conduits shall be subject to Architect/Engineer's direction and approval. Use only approved clamps on exposed conduit.
- J. Apply two coats of asphaltum paint to all underground metallic conduits. Carefully retouch any breaks in paint and allow drying before covering with earth. Leave exposed until after Architect/Engineer's inspection. Pittsburg Standard Rob-Kote may be used in lieu of painting.
- K. Conduit shall be sized in accordance with the latest National Electrical Code except that no conduit shall be smaller than 1/2" unless otherwise noted. Conduit shall be sized larger than required above when so shown on the drawings or when required by local Code.
- L. No conduit with an external diameter larger than 1/3 the thickness of the slab shall be placed in the slab. Conduits in slab shall not be spaced closer than 3 diameters on center.
- M. All exposed conduit threads, metal supports, etc., exposed to elements or exterior of building shall be painted with rust preventive paint.
- N. A 200 lb. test nylon pull cord shall be installed in all empty conduits.
- O. All conduit connections to sheet metal cabinets or enclosures subject to the elements shall be terminated using raintight hubs.
- P. Any conduit stubbed out for future shall be capped with a plastic cap and marked with a 2" minimum red metal tag which identifies conduit origin. Conduits stubbed up above grade or roof shall be tagged on the conduit. Conduit stubbed out below grade shall be tagged on nearest building wall, curb, etc., directly over the conduit run. All empty conduits shall have pull wires.
- Q. Conductors shall not be installed in raceways until the raceway is completely installed, free of any foreign matter, and dried.
- R. Install pull boxes in all runs having more than 270 degrees total bending (all directions combined and each complete offset counting as 90 degrees) or in runs more than 200' long.
- S. Unless otherwise stated in these specifications or noted on the drawings, all raceway penetrations shall be made only at perpendicular angles to the penetrated surfaces. In no case shall conduit which is run along exterior walls penetrate insulation or vapor barriers.
- T. Raceways not concealed in slabs or walls shall be securely anchored at regular intervals in accordance with NFPA 70 "NEC".

- U. Use only galvanized pipe straps, wall brackets, or ceiling trapezes anchored with toggle bolts, expansion bolts, metal screws, or wood screws as appropriate.
- V. Ceiling trapezes shall be supported by quarter-inch minimum diameter all-thread rods securely attached to the structure ceiling.
- W. Raceways shall not be supported from the finished ceiling, mechanical duct work, piping, or from other equipment.
- X. Straps and hangers shall be in accordance with the National Electrical Code and as recommended by the raceway manufacturer.
- Y. Ceiling tie wire used to support conduit or devices is strictly prohibited.
- Z. Install connectors and couplings per the requirements of the Manufacturer. Tighten to torque requirements.
- AA. Conduits which extend through the roof to roof top equipment shall be galvanized rigid protected with a weatherproof and watertight pate roof boot or equal. All penetrations through roof and pate roof boots shall be approved by the roof warranty guarantor and be accepted by the roof warranty guarantor prior to use. Written authorization by roofing company shall be provided during submittal phase.

END OF SECTION

SECTION 260534 - RACEWAYS - NON-METALLIC**PART 1 - GENERAL****1.1 SCOPE:**

- A. This section deals with the materials to be used as raceways where shown on the drawings or specified as non-metallic conduit.

1.2 WHERE USED:

- A. Non-metallic conduit shall be used below grade only as permitted by the NEC, and as hereinafter specified, or as approved by the Owner's Authorized Representative. Non-metallic conduit shall, however, convert to rigid metal conduit prior to leaving below finish grade areas and concrete slab in all applications. Non-metallic conduit shall not be used above grade except for grounding systems. All stub ups, including elbows, thru slab, or from below grade, shall be rigid steel unless otherwise noted. Conduit adapters shall be used in transition. Conduit system for grounding conductors only shall be PVC in back of house or concealed locations only without metallic components, as permitted by codes and standards.

PART 2 - PRODUCTS**2.1 SCHEDULE 40 RIGID PVC:**

- A. Conduit shall be composed of polyvinylchloride and shall be UL rated Type 40 for use with 90 C degree rated conductors. Conduit shall conform to NEMA standards and applicable sections of NEC.
- B. Minimum size shall be 3/4"

2.2 FITTINGS:

- A. All couplings, adapters, end bells, reducers, etc., shall be of same material and by the same manufacturer as conduit.

2.3 MANUFACTURER:

- A. The conduit manufacturer shall have had a minimum of five years experience in the manufacture of the products. Non-metallic raceways shall be as manufactured by Carlon or Owner approved equal.

PART 3 - EXECUTION**3.1 INSTALLATION:**

- A. All elbows, bends, etc., shall be either factory bends or made with an approved heat bender. Direct flame shall not be applied to conduit.

- B. Installation of rigid non-metallic conduit shall comply with Article 352 of the National Electrical Code (NFPA 70) and these specifications.
- C. Provide suitable expansion fittings as required on all raceways which are installed in walls subject to expansion and on raceways which penetrate expansion joints.
- D. Provide a continuous, insulated, grounding conductor in every rigid, non-metallic raceway even if not shown on the drawings. The grounding conductor shall be connected to ground at each end of the raceway in accordance with Article 250 of the National Electrical Code (NFPA 70).
- E. Where rigid non-metallic conduit transitions to metallic conduit, the location of the transition shall be underground.
- F. All cuts shall be made with an approved saw and ends de-burred.
- G. No PVC conduit shall be run exposed, or above grade.
- H. All joints shall be made as follows: Clean the outside of the conduit to the depth of the socket, and the inside of the socket with an approved primer (colored purple) cleaner. Apply solvent cement to the interior of the socket and exterior of conduit, making sure to coat all surfaces to be joined. Insert conduit into the socket and rotate 1/4 to 1/2 turn and allow to dry.
- I. Solvent cement shall be Rectorseal Gold #844 by the Rectorseal Corporation Meeting ASTM D2584.
- J. Provide a continuous 6" wide, yellow plastic, underground utility marker tape above the full length of all underground conduits. Minimum depth 1'-0" below finished grade and 1'-0" above conduit.
- K. In long sections of installed P.V.C. conduit, the Contractor shall use 90 degree elbow fittings in lieu of installing fabricated sweeps.

END OF SECTION

SECTION 260535 - BOXES FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SCOPE:**

- A. This section outlines the quality, type and installation of outlet boxes, junction boxes and gutters (wireways) for general and special use.

PART 2 - PRODUCTS**2.1 GENERAL:**

- A. All boxes and fittings shall be labeled by Underwriters' Laboratories, Inc.
- B. Interior outlet boxes shall be galvanized steel constructed with stamped knockouts in back and sides, and threaded holes with screws for securing box coverplates or wiring devices.
- C. Weatherproof outlet boxes shall be corrosion-resistant cast type suited to each application and having threaded conduit ends, cast face plate with spring-hinged waterproof cap suitably configured, gasket, and corrosion-proof fasteners.
- D. Provide outlet box accessories as required for each installation, including mounting brackets, wallboard hangers, extension rings, device rings, outlet boxes, and corrosion-resistant knockout closures compatible with outlet boxes being used and meeting requirements of individual wiring situations.
- E. Pull boxes and junction boxes shall be constructed of code gauge galvanized sheet steel. Provide pull boxes with screw-on covers of the type and size to suit each respective location and installation. Boxes shall have continuously welded seams and shall be equipped with steel nuts, bolts, screws, and washers. Provide cast metal, gasketed type pull boxes for outdoor locations.
- F. All boxes shall be sized as required by NFPA 70.
- G. NOTE: PVC junction boxes are strictly prohibited.

2.2 OUTLET BOXES:

- A. Shall be standard type, with knockouts, made of hot dipped galvanized steel as manufactured by Steel City, Raco or Appleton.
- B. Ceiling outlet boxes shall be 4" octagon or square with plaster ring 1-1/2" deep or larger when required due to number of wires.

- C. Boxes shall be provided with approved 3/8" fixture studs where required.
- D. Except when located in exposed concrete block, switch and receptacle boxes shall be 4" square with plaster or masonry rings for single gang installation. Appropriate gang boxes shall be used for mounting ganged switches.
- E. When installed in exposed concrete block, switch and receptacle boxes shall be masonry type stamped steel boxes.

2.3 JUNCTION BOXES AND PULL BOXES (INTERIOR):

- A. Sheet Metal: Shall be standard NEMA 1 type with hinged lockable cover, with knockouts, made of hot dipped galvanized steel as manufactured by Steel City, Raco or Appleton.
- B. Cast: Shall be type FS, FD, JB, GS, or SEH as required for application.
- C. Mounting Panel: Provide removable plywood internal mounting panel for component installation.

2.4 JUNCTION AND PULL BOXES (EXTERIOR):

- A. Shall be precast concrete for all below grade exterior use and where shown. All boxes installed above grade shall be NEMA 3R weatherproof and watertight, or as indicated on the drawings.
- B. Precast concrete below grade boxes located in exterior locations shall have 28-day concrete compressive strength = 4500 psi, and be designed for H-20-44 loading. Install pull eyes and inserts for cable rack in two sides of box. Contractor shall install box at depth where top of box is 3 inches above final surrounding grade elevation. Provide beaded weld lettering on cover, indicating service enclosed IE "systems", "power", etc.

2.5 CABINETS:

- A. Comply with UL 50, "Electrical Cabinets and Boxes" and NEMA ICS 6.
- B. Construction: Sheet steel, NEMA 12 class except as otherwise indicated. Cabinet shall consist of a box and a front consisting of a one piece frame and a hinged door. Arrange door to close against a rabbet placed all around the inside edge of the frame, with a uniformly close fit between door and frame. Provide concealed fasteners, not over 24" apart, to hold fronts to cabinet boxes and provide for adjustment.
- C. Provide flush or concealed door hinges not over 24" apart and not over 6" from top and bottom of door. For flush cabinets, make the front approximately 3/4" larger than the box all around. For surface mounted cabinets, make front same height and width as box.
- D. Doors: Double doors for cabinets wider than 24".
- E. Locks: Combination spring catch and key lock, with all locks for cabinets of the same system keyed alike. Locks shall be of a type to permit doors to latch closed without locking. All cabinets to be provided with locks.
- F. Mounting Panel: Provide removable plywood internal mounting panel for equipment and component installation.

- G. Provide color-coded identification nameplates for all junction boxes over 6" x 6" square per specification SECTION 26 05 01 - ELECTRICAL SCOPE.
- H. Cabinets shall be Square D #24366, surface mounted with integral lockable cover and internal plywood backboard.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Comply with applicable portions of the National Electrical Contractor's Association's (NECA) "Standard of Installation".
- B. Install all boxes and fittings in compliance with NFPA 70, the manufacturer's written instruction, and with recognized industry practices.
- C. For locations exposed to weather or moisture (interior or exterior), provide weatherproof boxes and accessories.
- D. Install pull boxes in all raceways runs having more than 270 degrees total bending (all directions combined and each complete offset counting as 90 degrees) or in runs more than 200' long.
- E. Provide knockout closures to cap unused knockout holes where blanks have been removed, and plugs for unused threaded hubs.
- F. Boxes and conduit bodies shall be located so that all electrical wiring is accessible.
- G. All boxes shall be sized per NEC Article 370.
- H. Install pull boxes and wire troughs with front covers accessible per code requirements.
- I. All flush floor outlets shall be leveled and flush with floor; shall be parallel and perpendicular to building construction lines and shall be compatible with floor material used. Verify exact location of floor boxes with Owner's Authorized Representative prior to concrete pour. Maintain fire rating through floor.
- J. All recessed boxes shall be installed in a flush rigid manner with box lines at perpendicular and parallel angles to finished surfaces. Boxes shall be supported by appropriate hardware selected for the type of surface from which the box shall be supported. For example, provide metal screws for metal, wood screws for wood, and expansion devices for masonry or concrete.
- K. The Contractor shall coordinate work with that of all trades so that each electrical box is the type suitable for the wall or ceiling construction provided.
- L. Provide supporting channel and hardware as necessary to support boxes, enclosures, and cabinets.

3.2 INSTALLATION OF OUTLET BOXES:

- A. Outlet boxes shall be securely fastened to structural members and shall not be supported by dry wall, gypsum board, plaster, etc. The device or plate installed in conjunction with the outlet box shall not be used for support.
- B. Surface fixture outlet boxes shall be set so edge of cover comes flush with finished surface.
- C. There shall be no more knockouts opened in any outlet box than are actually required.
- D. Boxes shall be sealed during construction.
- E. Back-to-back boxes shall be staggered at least 12" or as required by UL listing for rated walls and shall be installed using UL rated Putty packs or equal.
- F. Under no circumstances shall thru-the-wall or back to back boxes be used.
- G. Outlet boxes two gangs and wider shall not be supported by attachment clips or any means which supports the box from less than two opposite sides. Such outlet boxes in stud walls shall be supported securely by support members spanning between studs.

3.3 INSTALLATION OF JUNCTION BOXES:

- A. Provide junction or pull boxes where shown on the drawings and as required to facilitate installing conductors. Such boxes shall be "Code" sized unless required to be larger by the plans or other sections of this specification. All junction boxes shall be accessible.
- B. Junction boxes shall be securely fastened to the building structure independent of ductwork, plumbing, etc. Junction boxes shall not be supported by conduit fittings.
- C. Boxes to be embedded in concrete shall be properly leveled and anchored in place before the concrete is poured.
- D. There shall be no more knockouts opened in any box than are actually required.
- E. Boxes shall be properly protected during construction and shall be cleaned of all foreign matter before conductors are installed.
- F. All junction boxes shall be located a minimum of 12" and maximum of 36" from ceiling grid. Overhead junction boxes may not be installed where accessibility is dependent on removal of a lighting fixture or access cover. No junction shall be located above drywall ceiling. All junction boxes' locations shall be coordinated with all other trades such that all are accessible.
- G. Wall mounted junction boxes and terminal cabinets shall be mounted at a maximum height of 60" AFF.

3.4 INSTALLATION OF GUTTERS:

- A. Conductors serving a wiring gutter shall be extended without reduction in size for the entire length of the gutter.

END OF SECTION

SECTION 260923 - LIGHTING OCCUPANCY SENSORS**PART 1 – GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Wall box mounted, wall/corner mounted, and ceiling mounted occupancy sensors including dual technology, ultrasonic, and passive infrared technologies. This includes self contained PIR sensors as well as low voltage sensors that work with Switchpacks.
- B. Related Sections:
 - 1. Section 260926 – Relay Control Panels: Lighting panels (switching)

1.2 REFERENCES

- A. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE)
 - 1. C62.41-1991 – Recommended Practice for Surge Voltages in Low Voltage AC Power Circuits.
- B. ASTM International (ASTM)
 - 1. D4674 -02a Standard Test Method for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Fluorescent Lighting and Window-Filtered Daylight.
- C. Canadian Standards Association (CSA).
 - 1. CSA C22.2 # 14 Industrial Control Equipment
 - 2. CSA C22.2 # 184 Solid-State Lighting Controls
 - 3. CSA C22.2 # 156 Solid-State Speed Controls
- D. International Electrotechnical Commission .
 - 1. (IEC) 801-2 Electrostatic Discharge Testing Standard.
 - 2. IEC/EN 60669-2-1 Switches for household and similar fixed electrical installations - electronic switches.
- E. International Organization for Standardization (ISO)
 - 1. 9001:2000 – Quality Management Systems.
- F. National Electrical Manufacturers Association (NEMA)
 - 1. WD1 (R2005) - General Color Requirements for Wiring Devices.
- G. Norma Oficial Mexicana (NOM).
 - 1. NOM-003-SCFI Productos eléctricos - Especificaciones de seguridad (Electrical products - Safety Specifications)
- H. Underwriters Laboratories, Inc. (UL):
 - 1. 94 – Flammability Rating
 - 2. 916 – Energy Management Equipment.
 - 3. 508 (2005) - Standard for Industrial Control Equipment.
 - 4. 244A – Appliance Controls
 - 5. 935 (2005) - Fluorescent Ballasts

1.3 SYSTEM DESCRIPTION

- A. Permanently installed

1. Wall switch occupancy sensors
2. Ceiling mounted occupancy sensors
3. Switchpacks

1.4 SUBMITTALS

- A. Submit under provisions of Section 013300.
- B. Specification Conformance Document: Indicate whether the submitted equipment:
 1. Meets specification exactly as stated.
 2. Meets specification via an alternate means and indicate the specific methodology used.
- C. Shop Drawings; include:
 1. Load schedule indicating actual connected load, load type, and voltage per circuit, circuits and their respective control zones, circuits that are on emergency, and capacity, phase, and corresponding circuit numbers.
 2. Schematic of system.
 3. Lighting plan clearly marking product type, location and orientation of each sensor.
- D. Product Data: Catalog specification sheets with performance specifications demonstrating compliance with specified requirements.

1.5 QUALITY ASSURANCE

- A. Manufacturer: Minimum 20 years' experience in manufacture of occupancy sensor lighting controls.
- B. Manufacturer's Quality System: Registered to ISO 9001:2000 Quality Standards, including in-house engineering for product design activities.
- C. Occupancy Sensing Lighting Controls:
 1. Listed by UL specifically for the required loads. Provide evidence of compliance upon request.
- D. Installer Qualifications: Installer shall be one who is experienced in performing the work of this section, and who has specialized in installation of work similar to that required for this project.
- E. Source Limitations: To assure compatibility, obtain occupancy sensors from a single source with complete responsibility over all lighting controls, including accessory products. The use of subcontracted component assemblers is not acceptable.

1.6 PROJECT CONDITIONS

- A. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
 1. Ambient temperature: 0° to 40° C (32° to 104° F).
 2. Relative humidity: Maximum 90 percent, non-condensing.
 3. Occupancy Sensors must be protected from dust during installation.

1.7 WARRANTY

- A. Provide manufacturer's 5-year parts warranty.

1.8 MAINTENANCE

- A. Make ordering of new equipment for expansions, replacements, and spare parts available to end user.
- B. Make new replacement parts available for minimum of ten years from date of manufacture.
- C. Provide factory direct technical support.

PART 2- PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturer: Eaton Lighting Systems
- B. Substitutions:
 - 1. All proposed substitutions (clearly delineated as such) must be submitted in writing for approval by the design professional a minimum of 10 working days prior to the bid date and must be made available to all bidders.
 - 2. Proposed substitutes must be accompanied by a review of the specification noting compliance on a line-by-line basis.
 - 3. By using pre-approved substitutions, the contractor accepts responsibility and associated costs for all required modifications to circuitry, devices, and wiring.
 - 4. Provide complete engineered shop drawings (including power wiring) with deviations for the original design highlighted in an alternate color to the engineer for review and approval prior to rough-in.

2.2 SENSOR PERFORMANCE REQUIREMENTS

- A. Sensing mechanism:
 - 1. Infrared: Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
 - 2. Ultrasonic:
 - a. Utilize an operating frequency of 32 kHz or 40 kHz that shall be crystal controlled to operate within plus or minus 0.005% tolerance.
 - b. Utilize Doppler shift ultrasonic detection technology.
 - 3. Dual technology:
 - a. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
 - b. Utilize an operating frequency of 32 kHz or 40 kHz that shall be crystal controlled to operate within plus or minus 0.005% tolerance.
 - c. Incorporate Doppler shift ultrasonic and passive infrared motion detection technologies. Products that react to noise or ambient sound shall not be considered.
- B. Power failure memory:
 - 1. Controls incorporate non-volatile memory. Should power be interrupted and subsequently restored, settings and parameters saved in protected memory shall not be lost.
- C. Designed and tested to withstand discharges without impairment of performance when subjected to discharges of 15,000 volts per IEC 801-2.
- D. Products tested in identical manner, complaint to NEMA WD 7 -2011 Occupancy Motion Sensors Standards.
- E. Sensor shall have time delays from 10 to 30 min.
- F. When specified, sensors shall automatically adjust time delay and sensitivity settings.

- G. All sensors shall provide an LED as a visual means of indication at all times to verify that motion is being detected during both testing and normal operation.
- H. All sensors shall have readily accessible, user adjustable settings for time delay and sensitivity. Settings shall be located on the sensor (not the control unit) and shall be recessed to limit tampering.
- I. Where specified, sensor shall have an internal additional isolated relay with Normally Open, Normally Closed, and Common outputs for use with HVAC control, Data Logging and other control options. Sensors utilizing separate components or specially modified units to achieve this function are not acceptable.

2.3 LINE VOLTAGE CEILING MOUNTED OCCUPANCY SENSORS

- A. Product: OAC-DT-2000-
- B. Provide all necessary mounting hardware and instructions.
- C. [Provide a recessed bypass manual "override on" key on each sensor.]
- D. Provide a mechanical air-gap on/off function for all sensors.
- E. Capable of detection of occupancy at desktop level up to 300 square feet, and gross motion up to 1000 square feet
- F. Shall accommodate loads from 0-800 watts at 120 volts; 0 to 1200 watts at 277 volts and shall have 180 degree coverage capability.
- G. Shall be able to have their visible plastic parts replaced, for color changes in the field, without removing the body of the control from the wall and without requiring special tools.
- H. Shall utilize Zero Crossing Circuitry which increases relay life, protects from the effects of inrush current, and increases sensor's longevity.
- I. Shall have no leakage current to load, in manual or in Auto/Off Mode for safety purposes and shall have voltage drop protection.
- J. Where specified, sensors shall offer daylighting foot-candle adjustment control and be able to accommodate dual level lighting.
- K. Where specified, dual relay sensors shall offer daylighting foot-candle adjustment control for either or both relays.
- L. Where specified, dual relay sensors shall offer a Bathroom Mode which keeps the second relay ON for an addition 8 minutes after the first relay has been turned off.
- M. Where specified, sensor packaging shall be 100% recycled [made entirely from post-consumer waste (100% post-consumer fiber content) as well as, 100% recyclable].
- N. Sensors shall be RoHS compliant
- O. Where specified, sensors shall offer integral Bi-level Automatic On (just one lighting level comes on automatically when occupancy is detected)

2.4 WALL / CORNER MOUNTED SENSORS

- A. Product: OAWC-P-120W
- B. Provide all necessary mounting hardware and instructions.
- C. Sensors shall be Class 2 devices.
- D. Provide an internal additional isolated relay with Normally Open, Normally Closed and Common outputs for use with HVAC control, Data Logging and other control options.
- E. Where specified, sensors shall offer daylighting footcandle adjustment control
- F. Where specified, sensor packaging shall be 100% recycled [made entirely from post consumer waste

(100% post consumer fiber content) as well as, 100% recyclable].

- G. Sensors shall be RoHS compliant.
- H. Where specified, sensors shall offer integral Bi-level Automatic On (just one lighting level comes on automatically when occupancy is detected)

2.5 OCCUPANCY WALL SWITCHES

- A. Product: OSW-P-0451-MV
- B. Provide vandal resistant wall switch sensors shall utilize a hard lens with a minimum 1.0 mm thickness.]
- C. Provide a recessed bypass manual "override on" key on each sensor.
- D. Provide a mechanical air-gap on/off function for all sensors.
- E. Capable of detection of occupancy at desktop level up to 300 square feet, and gross motion up to 1000 square feet
- F. Shall accommodate loads from 0-800 watts at 120 volts; 0 to 1200 watts at 277 volts and shall have 180 degree coverage capability.
- G. Shall be able to have their visible plastic parts replaced, for color changes in the field, without removing the body of the control from the wall and without requiring special tools.
- H. Shall utilize Zero Crossing Circuitry which increases relay life, protects from the effects of inrush current, and increases sensor's longevity.
- I. Shall have no leakage current to load, in manual or in Auto/Off Mode for safety purposes and shall have voltage drop protection.
- J. Where specified, wall switch sensors shall provide a field selectable option to convert sensor operation from Automatic On to Manual On.
- K. Where specified, sensors shall offer daylighting footcandle adjustment control and be able to accommodate dual level lighting.
- L. Where specified, dual relay sensors shall offer daylighting footcandle adjustment control for either or both relays.
- M. Where specified, dual relay sensors shall offer a Bathroom Mode which keeps the second relay On for an addition 8 minutes after the first relay has been turned off.
- N. Where specified, sensors shall feature a universally recognized light bulb icon for end user ease of identification of use.
- O. Where specified, dual relay sensors shall feature universally recognized light bulb and fan icons for end user ease of identification of use.
- P. Where specified, sensor packaging shall be 100% recycled [made entirely from post consumer waste (100% post consumer fiber content) as well as, 100% recyclable].
- Q. Sensors shall be RoHS compliant.
- R. Where specified, sensors shall have an EcoMeter that provides a visual indicator of energy usage, increasing end user awareness and reminding individuals to take control of their lighting to maximize energy savings.
- S. Where specified, low voltage sensors shall have a Tracking/HVAC Mode that allows the load connected to the Form C BAS relay to remain on when the lights are turned off manually.
- T. Where specified, sensors shall have a tamper-proof Automatic Only Mode that automatically turns lighting on and off without requiring a user to push a button.

2.6 SENSOR SWITCHPACKS

- A. Product: SP20-MV
- B. Plenum rated]
- C. Control wiring between sensors and control units shall be Class 2, 18-24 AWG, stranded U.L. Classified, [PVC insulated] [TEFLON jacketed cable suitable for use in plenums].
- D. Integrated, self-contained unit consisting internally of an isolated load switching control relay [and a power supply to provide low voltage power].
- E. Shall be compatible with incandescent, magnetic or electronic low voltage, and magnetic or electronic fluorescent, as well as motor loads.
- F. Shall be capable of controlling receptacle or plug loads. [SPRC-R-20-120], [SP-R-20-120]

2.7 SOURCE QUALITY CONTROL

- A. Perform full-function testing on 100% of all system components and panel assemblies at the factory.

PART 3- EXECUTION

3.1 INSTALLATION

- A. Install equipment in accordance with manufacturer's installation instructions.
- B. Provide complete installation of system in accordance with Contract Documents.
- C. Provide equipment at locations and in quantities indicated on Drawings. Provide any additional equipment required to provide control intent.

3.2 TESTING

- A. Upon completion of all wiring and after all fixtures are installed and lamped, a representative shall check the installation prior to energizing the system. Each installed occupancy sensor shall be tested in the Test Mode to see that lights turn OFF and on based on occupancy.
- B. At the time testing, the owner's representative shall be thoroughly instructed in the proper operation of the system.

END OF SECTION

SECTION 262413 - DISTRIBUTION SWITCHBOARDS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. General: Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work specified of this section.

1.2 DESCRIPTION

- A. Description of System: Provide factory-assembled, metal-enclosed switchboard for service entrance from line terminals to outgoing feeder terminals, complete, installed, and tested in place.
- B. Description of System: Provide factory-assembled, metal-enclosed switchboard for distribution and control of power from line terminals to outgoing feeder terminals, complete, installed, and tested in place.
- C. General: Switchboard shall include all main and branch protective devices, related equipment as required or as listed on drawings, with all necessary interconnections, instrumentation, control wiring, etc.

1.3 DISTRIBUTION SWITCHBOARDS QUALITY ASSURANCE

- A. ANSI: The latest edition of the Reference Standards for the American National Standards Institute shall apply as follows;
 - 1. ANSI Y32.2 - Graphic Symbols for Electrical and Electronic Diagrams.
 - 2. ANSI Z55.1 - (R1973) Gray finishes for Industrial Apparatus and Equipment.
 - 3. ANSI C57.13 - Instrument transformers
- B. NEMA: National Electrical Manufacturers Association shall apply as follows;
 - 1. NEMA PB2, Dead front Switchboards.
 - 2. NEMA AB1, for molded case circuit breakers and switches.
 - 3. NEMA MS1 for enclosed switches.
- C. NFPA: The latest edition of the National Fire Protection Association shall apply as follows;
 - 1. NFPA 70, National Electrical Code (NEC).
 - 2. Refer to Section 26 05 00 for additional references.
- D. UL: The latest edition of the Underwriters' Laboratories, Incorporated shall apply as follows:
 - 1. UL Electrical Construction Materials List Switchboards-dead front type (384 W4) WEVZ.
 - 2. UL 891-Dead front switchboards.
 - 3. UL 50 Cabinets and boxes.

4. UL 38 Enclosed and dead front switches.
 5. UL 489 Molded case circuit breakers.
 6. UL 891 Dead front switchboards.
 7. UL 943 Ground fault circuit interrupters.
 - E. Source Quality Control: Tests to meet NEMA PB2 requirements.
 - F. Design Tests: Rated Continuous current test, short circuit current test, Enclosure test, Dielectric test.
 - G. Production Tests: Perform tests on completed switchboard assembly.
 - H. Type: Dielectric tests, Mechanical operation test, Grounding tests, Control wiring tests, Electrical operation tests.
- 1.4 SUBMITTALS - DISTRIBUTION SWITCHBOARDS
- A. General: Submit layouts showing concrete pad dimensions, conduit entrance and available space, bus duct connections, electrical rating, nameplate nomenclature, single-line diagram (in accordance with ANSI Y32.2) indicating all connections and control.
 - B. Shop Drawings: Shop Drawings shall be submitted for each switchboard and shall clearly indicate all of the following information;
 1. Enclosure elevations, studs and details.
 2. Complete Construction Information
 3. U.L. Label
 4. Each overcurrent device amperage rating, circuit number and position/location in the switchboard.
 5. Electrical characteristics
 6. Dimensions, (width, depth, height, weight)
 7. Switchboard classification
 8. Frame size, rating and interrupting capacity of each breaker, and of total assembly.
 9. Horsepower rating at rated voltage of fused switches and/or breakers.
 10. Size and type of fuses being provided.

11. Ranges of all meters.
 12. Type of labeling for each overcurrent device and load (Provide at least one sample with shop drawing).
 13. Main switchboard nameplate indicating project name; Architect, Engineer and Contractor.
 14. Product data for switchboard mounted transformers; transfer switches; main fused "bolt-loc" switches; power breaker; or other specialties clearly and/or separately called out in the contract documents.
 15. Bus bar size, type arrangement and spacing (Phase, neutral and ground bar).
 16. Transparency log paper time current curves for protective relays, current and potential transformer excitation and saturation curves, and fuses.
 17. Protective relay instruction books.
 18. Shipping sections.
 19. Lug sizes for cables on all switches or breakers.
 20. Incoming lug sizes.
- C. Product Data: Manufacturer's written recommendations for storage, protection, handling, installation instructions and field test requirements. Record all field tests, itemize data and submit at end of project with project manual.
- D. Test Reports: Reports of production and field tests.
- E. Operations and Maintenance Data: Provide and comply with manufacturer's instructions for tightening bus connections, performing cleaning, operating and maintaining switchboard.

1.5 QUALITY ASSURANCE

A Standards: The switchboard shall comply with the latest edition of the following standards:

1. American National Standards Institute (ANSI):
 - a. ANSI Y32.2, Graphic Symbols for Electrical and Electronic Diagrams.
 - b. ANSI Z55.1 (R1973) Gray Finishes for Industrial Apparatus and Equipment.
2. National Electrical Manufacturers Association (NEMA) PB2 - Tests.
3. National Fire Protection Association (NFPA).
 - a. NFPA 70-1993, National Electric Code (NEC).
4. Underwriters Laboratories (UL)

- a. (384 W4) WEVZ Switchboards
- b. 891 Dead Front Switchboards

B. Source Quality Control:

1. Design Tests:

- a. Rated Continuous current test.
- b. Short circuit current test.
- c. Enclosure test.
- d. Dielectric test.

2. Production Tests:

- a. Perform tests on completed switchboard assembly.
- b. Type:
 - 1) Dielectric tests.
 - 2) Mechanical operation test.
 - 3) Grounding tests.
 - 4) Control wiring tests.
 - 5) Electrical operation tests.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Handling: Only lift switchboard using eyes, yokes, and skids provided by manufacturer.
- B. Storage: Do not store indoor switchboard exposed to weather.
- C. Protection: Physically protect switchboard against all damage. Cover switchboard with suitable material to avoid damage to finish.

1.7 ACCEPTABLE MANUFACTURERS

- A. Acceptable Manufacturers: Acceptable manufacturers shall be ITE Siemens, Square D, and Eaton.

PART 2 - PRODUCTS

2.1 DISTRIBUTION SWITCHBOARDS

- A. General: Switchboards shall be dead front with front accessibility required. The switchboard frame shall be of formed code gauge steel rigidly bolted together to support all coverplates, bussing and component devices during shipment and installation. Steel base channels shall be bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting. Each switchboard section shall have an open bottom and an individually removable top plate for installation and termination of conduit. All front covers shall be screwed on and removable and all doors shall be hinged with removable hinge pins. Top and bottom conduit areas shall be clearly indicated on shop drawings. Switchboards shall be freestanding and completely self supporting structures, 90" high.

2.2 FINISH

- A. Preparation: All steel surfaces shall be chemically cleaned and treated to provide a bond between paint and metal surfaces to help prevent the entrance of moisture and formation of rust under the paint film.
- B. Color: The switchboard exterior shall be finished in indoor light gray No. 61, ANSI Z55.1.
- C. Coating: Apply corrosion-protective undercoating and allow to dry prior to final coat. Touch up any scratches prior to calling for final inspection.

2.3 BUSSING AND TERMINATIONS

- A. Bus bars: Buses shall be plated copper sized of sufficient size to limit the temperature rise to 65 degree C, based on UL tests. Bussing shall be of sufficient cross-sectional area to meet UL Standard 891 temperature rise. The bus structure shall be braced and rated to withstand mechanical forces exerted during short circuit current conditions when connected directly to a power source having a minimum 65,000 rms symmetrical amperes. A ground bus shall be provided and factory secured to each vertical section of switchboard.
- B. Bus Supports: All bus supports, connections and joints shall be bolted with hex-head bolts and Belleville washers to minimize maintenance requirements.
- C. Accessibility: Bus connections shall be front accessible. Each switchboard end section shall include all provisions for the addition of future sections.
- D. Space Provisions: Where space for future is called for on drawings, provide all necessary hardware and bus, except device connecting straps.
- E. Ratings: Switchboard through bus shall have continuous current rating of 100% of main device frame size.
- F. Terminations: All line and load termination points shall be suitable for the quantity and size of terminated conductors as indicated on the drawings and shall be suitable for each type of conductor material. Terminations shall be front accessible.
- G. Hardware: All hardware shall be manufactured from high tensile strength steel and have a suitable protective finish.

2.4 ACCESSORIES

- A. General: Switchboard shall be provided with adequate lifting means from the factory, and shall be capable of being rolled or moved into installation position and bolted directly to its 4" concrete base (housekeeping pad) without the use of floor sills.
- B. Provide main circuit breaker with complete circuit monitor system, Square D PM870 or equal.

2.5 CONTROL POWER AND WIRING

- A. General: Where electrically operated devices or ground fault relays requiring external power are indicated, provide 120-V control circuits supplied through secondary disconnect devices from internal control power transformer.
- B. Control Power Fuses: Include primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- C. All control wiring conductors shall have heat shrink identification labels on each end of termination. Terminations shall be made to screw terminal strips using accepted conductor terminals. All points of terminal strips shall be labeled to match conductor labeling.

2.6 MAIN SECTION

- A. General: The service disconnect device shall be as specified herein and shall be totally front accessible and front connectable. Main device shall be provided with ground fault protection and shunt trip. Main circuit breaker shall be insulated case breaker type with solid-state with adjustable settings for long-time, short time, instantaneous, long-time delay and short time delay. Impending trip and diagnostic indications shall be visible on the front of the circuit breaker.
- B. Ground Fault Protection: Ground fault protection when required system shall be provided as an integral function to the Main Circuit Breaker and shall include field adjustable current and time delay settings.
 - 1. A ground sensor on line side of main switch encircling all phase and neutral conductors connected to an adjustable solid state ground relay switch which initiates automatic shunt tripping of the main and/or branch circuit interrupting devices.
 - 2. System shall be adjustable from 200 to 1200 primary amperes, and time current characteristics shall provide 6 cycle operation at about ten times setting.
 - 3. Relay output shall operate at 120 volts A.C. fused source from main bus. Provide all terminal blocks, transformer, auto-reset fuses, interconnecting wiring, etc.
 - 4. Submit relay curves and all main/branch breakers and provide coordination study.

2.7 AUXILLIARY SECTION

- A. Provide matching auxiliary section for the switchboard for wire access to secondary conductors, as required.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Preparation: Examine area to receive switchboard to assure that there is adequate clearance to meet NEC requirements and normal maintenance issues for switchboard installation. Check that housekeeping pads (concrete base) are level and free of irregularities. Start work only after any unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Compliance: Provide switchboard complete in accordance with manufacturer's written instructions, NEC, and all applicable codes.
- B. Mounting: Mount switchboard on 4" high housekeeping pad (concrete base). Pad shall extend 6" beyond switchboard edge on all sides with all equipment installed.

3.3 FIELD QUALITY CONTROL

- A. General: Provide field tests prior to energization as follows;
 - 1. Megger check and record all data, of phase to phase and phase to ground insulation levels.
 - 2. Continuity.
 - 3. Short Circuit.
 - 4. Proper phase relationship.
- B. Provisions: Perform tests according to switchboard manufacturer's instructions.

3.4 ADJUSTMENT AND CLEANING

- A. Adjustments: Adjust operating mechanisms for free mechanical movement.
- B. Connections: Tighten bus connections and mechanical fasteners.
- C. Finish: Touch-up scratched or marred surfaces to match original finish.

END OF SECTION

SECTION 262416 - PANELBOARDS**PART 1 - GENERAL****1.1 SCOPE:**

- A. This section outlines the requirements for panelboards and modular meter centers.
- B. Panelboards shall be as manufactured by ITE Siemens, Square D, Eaton,

PART 2 - PRODUCTS**2.1 PANELBOARDS:**

- A. Panelboards shall be dead front type and shall be in accordance with Underwriters' Laboratories, Inc., standard for panelboards and enclosing cabinets and so labeled.
- B. The panel-boards and circuit protection devices shall be manufactured and tested according to the latest applicable standards of the following agencies:
- C. UL 50, Enclosures and Electrical Equipment
- D. UL 67, Panelboards
- E. UL 489, Molded Case Circuit Breakers and Circuit Breaker Enclosures
- F. UL 943, Ground Fault Circuit Interrupters
- G. NEMA PB1, Panelboards
- H. NEMA PB1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or less.
- I. NEMA AB1, Molded Case Circuit Breakers and Molded Case Switches
- J. Federal Spec W-P 115, Rev. C, Panel, Power Distribution
- K. ANSI/NFPA 70, National Electrical Code
- L. ANSI/NEMA KS1, Enclosed and Miscellaneous Distribution Equipment Switches (600V)

2.2 PANELBOARD BOXES:

- A. Panelboard boxes shall be fabricated from sheet steel. A metal framed circuit directory card holder with clear plastic covering shall be welded on the inside of door. Panelboards shall be for surface mounting unless otherwise noted on the drawings. All Panelboards shall have internal key tumbler locks.
- B. Ampacity and service voltage of main bus, lugs or main breakers and branch circuit breakers shall be as indicated in schedules. Entire panelboard shall be capable of withstanding a short circuit not less than the interrupting capacity of any breaker in the panel. Bus connectors shall be for distributed phase arrangement and shall be copper. Bussing shall be copper.

2.3 GROUND BUS:

- A. Copper ground bus shall be furnished in all panelboards.
- B. Provide Isolated ground bus as indicated on the drawings

2.4 NEUTRAL BUS:

- A. Full size copper neutral bus shall be furnished.

2.5 MAIN LUGS:

- A. Main lugs shall be rated for copper conductors and sized for conductors as shown.
- B. Standard lighting and power distribution panels shall be field convertible from Main Lug to Main Breaker with no increase in panel height. Field-addable mains (bussed connected) sub-feed breaker or feed-thru lug kits shall also be available, without utilizing any branch circuit space.

2.6 MAIN BREAKERS:

- A. Main breakers shall be provided as called for on the drawings.
- B. Main breakers and or branch circuit breakers shall be shunt trip type where called for on the drawings.

2.7 ASSEMBLY:

- A. Panelboards shall be factory assembled with branch breakers arranged as shown in schedules. Breakers shall be numbered vertically beginning top left. Breaker numbers shall be permanently attached to trim. Panel shall be minimum 20" wide, unless specifically noted otherwise.

2.8 CIRCUIT BREAKERS:

- A. Circuit breakers shall be bolt-on, quick break, quick make, thermal-magnetic type, for alternating current. Breakers shall trip free of the handle and tripping shall be indicated by the handle assuming a position between OFF and ON. Multi-pole breakers shall be internal common trip (handle ties are not permitted). Provide trip, frame, poles, and voltage rated circuit breakers as indicated on drawings. Circuit breakers serving air conditioning and refrigeration equipment shall be HACR rated from the factory by the manufacturer.

2.9 SPECIAL REQUIREMENTS:

- A. Any special requirements on the drawings or schedules, such as ground fault protection, circuit breakers, arc fault circuit breakers, increased interrupting capacity, shunt trip type circuit breaker, feed thru panel boards, Nema 3r enclosures etc., shall supersede these specifications, but only insofar as that particular requirement is concerned and as indicated. Provide integral step down transformer for 120 volt circuit for integral shunt trip modules where shunt trip coils are indicated to be provided.

2.10 MODULAR METER CENTERS

- A. Gangable and modular stackable metering shall be complete with: aluminum cross bussing and meter stacks.
- B. Minimum short circuit rating or integrated assembly shall not be less than 22,000 amperes.
- C. Meter bases shall conform to U.L. Standard 175, and be configured to conform to the serving utility requirements.
- D. Residential unit circuit breakers shall be 2-pole, with ampere ratings and series interrupting ratings to limit fault currents to less than 10,000 amperes. Provide permanent plastic identification label indicating the apartment unit served on each circuit breaker.

- E. Phase sequenced bussing shall be used throughout, with load balance as equal as possible. The individual meter sockets in each stack may be connected to any 2 phases and adjusted in the field to assure proper system load balance.
- F. Provide Modular Meter Center Main Overcurrent Devices, Modular Meter Center Tap Boxes and Modular Meter Center feed thru-type tap boxes. All devices shall be UL listed as complete system. Provide all increased connection lugs sized for all conductors as required to accommodate increased conductor size for voltage drop.

2.11 RESIDENTIAL LOAD CENTERS:

- A. Panels located within in residential units only, shall be load centers.
- B. Maximum allowable physical dimensions: \pm 16 inches wide by 3.5 inches deep per section.
- C. All load centers shall use molded case circuit breakers, and shall be rated for 22,000AIC in series with circuit breaker tenant mains at the modular meter centers.
- D. Completely sealed enclosure. Toggle type operating handle. Trip ampere rating and ON/OFF indication clearly visible.
- E. Thermal-magnetic trip-free, trip-indicating, quick-make, quick-break, with inverse time characteristic. Single-handle and common tripping on multi-pole breakers.
- F. External handle shall be suitable for locking in the OFF position.
- G. Silver alloy contacts with auxiliary arc-quenching devices.
- H. Breakers for lighting circuits shall be SWD rated.
- I. Provide arc fault / GFCI combination circuit breakers for all circuit breakers as required per NEC and local code in residential living units. Indication of protective function causing trip shall be indicated by LED on breaker front to assist troubleshooting the circuit
- J. Provide all increased connection lugs for load centers and Panelboards sized for all conductors as required to accommodate voltage drop.

PART 3 - EXECUTION

- A. All panel board dimensions shall be carefully checked and coordinated with the proper trades to insure proper mounting space and support.
- B. Wiring in panel board gutters shall be done in a neat and workmanlike manner. Wiring shall be grouped into neat bundles and secured with nylon 600v rated tie wraps within all panel boards, load centers and modular meter centers.

- C. All lugs shall be torqued as recommended by the manufacturer.
- D. Provide permanent plastic identification on cover for each panel board and load center indicating equipment name and voltage.
- E. Provide type written directories for each panel board and load center indicating the exact load and location of the load served.
- F. Load center construction shall only be utilized where located within residential units.

END OF SECTION

SECTION 262726 - WIRING DEVICES**PART 1 - GENERAL****1.1 SCOPE:**

- A. This section outlines the quality and requirements of the basic devices, switches, receptacles, etc., to be used and the installation instructions for the devices.

PART 2 - PRODUCTS**2.1 WIRING DEVICES:**

- A. Switches and receptacles shall be A.C. type of the kind indicated.
- B. Switches shall be specification grade silent operation toggle, rated for use at 20 amps, 120-277 volts AC.
SCHEDULE:

Acceptable Manufacturers

<u>Switch Type</u>	<u>Eaton-Arrow-Hart</u>	<u>Hubbell #</u>	<u>Bryant #</u>
20A SPST	1221	1221	4901
20A 3-way	1223	1223	4903

- C. Receptacles shall be specification grade tamper resistant type and shall be provided in duplex arrangement unless otherwise noted. . Devices for all residential apartment units and all in all public front of house areas visible to public shall be Decora style wiring devices with matching nylon cover plates.

Acceptable Manufacturers

<u>Receptacle Type</u>	<u>Eaton-Arrow-Hart</u>	<u>Hubbell</u>	<u>Bryant #</u>
20A Duplex 2P, 3W 125V, NEMA 5-20	TRBR20	5362T	5362T
20A Duplex xP 3W 125V NEMA 5-20 Isolated Grounding Type	IG5362	IG5362	BRY5362IG
Ground Fault Circuit Interrupters	VGf20	GF20	GF20

- D. Weatherproof receptacles shall be GFCI types with gasketed key lockable flip cover type cover plates. Cover plates shall be Eaton-Arrow-Hart #WIUMV-1X. Surge suppression type outlets shall be Arrow-Hart 5362BLS (blue) or equal.
- E. Receptacles provided for attachment of cord and plug equipment shall be heavy duty, specification grade, non-interchangeable, flush mounted types of the proper NEMA configuration to serve the equipment. Device NEMA configurations shall be verified prior to installation of circuit conductors. All power outlets shall be twist lock type.

- F. Contractor shall provide all final wiring pigtails for all dishwashers, disposals, ranges, microwaves, AHU, ACU, water heaters, and any other equipment or motor connection that is required.
- G. COMBINATION USB CHARGER TAMPER RESISTENT RECEPTACLES
Standard AC Duplex tamper resistant receptacle with two USB charging rated at 2.1 UL listed to UL 498 and UL 1310 Basis of Design product: Subject to compliance with requirements, provide Cooper; TR7746 (20A)
 - Device shall have an LED indicator to notify a user that a device is connected to the USB port for charging
 - Device shall have auto grounding feature.
 - Device shall have triple wipe blade contacts (Hot Neutral) and double wipe ground contacts to insure long term blade retention.

2.2 PLATES AND ACCESSORIES:

- A. All devices shall have proper plates, carpet flanges, trim, etc., as manufactured by same manufacturer as devices. Any telephone or other outlet which is not equipped with a plate furnished by others shall have one provided by this Contractor. Device plates shall be color and type as shown below.
- B. Finished and Residential Spaces: Devices for all residential apartment units and all public front of house areas including lobbies that are visible to public shall be Decora style devices with matching nylon cover plates.
 - 1. White Devices
 - 2. White Nylon Plates
- C. Unfinished and Back of House Spaces:
 - 1. Grey Devices
 - 2. Stainless Steel Plates
- D. Surface mounted devices in unfinished areas shall have galvanized plate with rounded edges.
- E. Flush floor outlets shall be mounted in Steel City, #664 Wire mold RFB-4 concealed service floor boxes, or Owner approved equal floor boxes with covers as indicated, plus communication or data side. Provide face plates for devices indicated. Floor boxes installed above first floor slab shall be constructed to maintain a one-hour fire rating. Provide flexible conduit connection where indicated. Provide concealed ¾" minimum conduit to IDF or MDF from communications side of floor box in all locations.

2.3 ELECTRICALLY OR MECHANICALLY HELD CONTACTOR AND TIME CLOCKS:

- A. Contactor for control of lighting circuits shall be Square D, Type L, Class 8903, or equivalent, in Allen-Bradley or Cutler Hammer. Contactor shall be mechanically (as indicated) operated, electrically or mechanically (as indicated) held type designed for two-wire control circuit, fully rated for tungsten, resistance, and ballast loads, and with 100 amp continuous load current rating and 480 volt voltage rating. Provide number of poles as required for circuits indicated. Contactors shall be furnished with NEMA 1 surface mounted enclosure unless otherwise called for on the drawings. All lighting contactors shall be identified as to circuits and loads controlled.
- B. Time Clocks: Electronic type with 7-day load control. Provide integral manual override feature, and spring wound or battery carryover. Unit shall be Intermatic #ET173C #ET70215CR.

PART 3- EXECUTION

3.1 INSTALLATION:

- A. All devices shall be installed so that only one wire is connected to each terminal.
- B. Install all components in accordance with the manufacturer's written instructions, NECA's "Standard of Installation", the applicable requirements of the National Electrical Code, and recognized industry practice.
- C. Coordinate location of boxes prior to rough in with mill work cabinets, built-ins, marker and tack board and all other trades.

3.2 MOUNTING HEIGHTS:

- A. Mounting heights are approximate. The exact locations and mounting heights shall be determined on the job and it shall be the Contractor's responsibility to coordinate with all trades to insure correct installation, i.e., over counters in or above back-splashes, in blocks walls, tile, and other specific construction features. Location of outlets mounted in built-ins, millwork, and cabinetry shall be verified. Outlets mounted in kick or toe spaces shall be mounted horizontally. Outlet boxes shall be mounted to prevent device plate from overlapping backsplash, trim, tile, etc. Locate so device plate will lay flat against surface completely around the perimeter of plate.
- B. Outlets, other than those coordinated with counter tops, shelves, and cabinets, shall be located with the center line of outlet boxes the following distance above the finished floor, unless otherwise indicated:
 - 1. Receptacles, General: 1'-6"
 - 2. Telephone Outlets: 1'-6"
 - 3. Switches, General: 3'-6"
 - 4. Receptacles, countertop maximum height: 3'-10"
- C. All device mounting heights shall be in accordance with requirements for making buildings accessible to the handicapped. (ADA)

3.3 GENERAL MOUNTING:

- A. Verify all door swings with the Architectural drawings. Locate boxes for light switches within 4" of door trim. Where switches are shown on the drawing grouped together they shall be installed under a single plate. Where required, barriers shall be provided in the outlet boxes.
- B. Where receptacles, telephone outlets, computer outlets, TV outlets and auxiliary system outlets are shown on the drawings grouped together they shall be installed with a maximum of 4" between outlets. Coordinate the actual dimensions in the field.
- C. Devices and associated plates shall not be used as supports. Outlet boxes shall be rigidly supported from structural members.

- D. Contractor shall review all drawings of the Architect and Interior design team in order to properly and finally locate all devices and lighting fixtures with the furniture, cabinet and millwork layouts.
- E. Back to Back to back devices and or device boxes and Panels shall not be utilized. Locate all boxes within a different stud frame area, and provide UL approved fire sealing and or Putty packs as required to maintain the UL listing between walls and floors.

END OF SECTION

SECTION 262816 - SAFETY SWITCHES**PART 1 - GENERAL****1.1 SCOPE:**

- A. This section deals with safety switches for branch circuits and general use.

PART 2 - PRODUCTS**2.1 SAFETY SWITCHES:**

- A. Switches shall be quick-make, quick-break, NEMA heavy duty type HD sized as shown on drawings and as specified, fused or non-fused as shown or as required to maintain NEMA and UL listing of equipment served. Switch blades shall be fully visible in the off position. Switches shall not utilize circuit breaker components or butt type blow-off contacts.
- B. Lugs shall be mechanical for copper conductors and sized for conductors as shown.
- C. Safety switches shall be of the same manufacturer as all other distribution equipment
- D. Switches shall be by Square D, Eaton, ITE Siemens

PART 3 - EXECUTION:**3.1 SAFETY SWITCHES:**

- A. Safety switches shall be installed as shown on the plans and in accordance with NEC. Locate for proper clearance and access.
- B. Disconnect switches for motors shall be rated in horsepower and shall be sized for motor served.
- C. Disconnect switches for non-motor loads shall be sized in accordance with equipment full load current. Safety switches shall be installed in NEMA 1 enclosures except where installed in locations subject to moisture within kitchens and/or installed outdoors in which case safety switches shall have a NEMA 3R steel enclosure and except where other types of enclosures are shown or indicated on the drawings.
- D. Adequate support shall be provided for mounting safety switches. Switches shall not be mounted directly to the equipment they serve. Switches shall be located so that the equipment served may be removed without dismantling the branch circuit.
- E. Mount safety switches 60" AFF to top of enclosure U.O.N.
- F. Provide Class R fuses and rejection clips for all fused disconnect switches serving Elevator motor connections.

- G. Provide permanent identification label for all safety switches.

END OF SECTION

SECTION 263213 - ENGINE GENERATORS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. General: Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work specified of this section.

1.2 DESCRIPTION

- A. General: This section describes materials, installation and testing of an engine generator set, diesel fuel tank both with integral main circuit breakers, and auxiliary support system, to be used for emergency and standby power in the event of a utility power failure. The unit shall be mounted in an interior location.
- B. Contractor shall provide complete integration and coordination with the Smoke evacuation system design in order to provide a complete and automatic emergency lighting and standby emergency power system in the event of a power outage. This shall include emergency lighting relays and all required wiring as required for a complete automatic and functional emergency lighting and standby system.
- C. Department of Environmental Protection Contact:
Glen Becker, Senior Environmental Specialist
Environmental Protection Division
Storage Tanks Compliance
800 Mercy Drive, Suite 4
Orlando, FL 32808
Office: 407-836-1453
glen.becker@ocfl.net

1.3 SUBMITTALS

- A. Shop Drawings: Submit shop drawings in accordance with Section 16010 of this specification.
- B. Submission: Show applicable ratings, sizes, materials, manufacturers and part number, and overall dimensions and weights, for the following equipment:
1. Itemized bill of material
 2. Manufacturer and model of engine
 3. Manufacturer and model of generator
 4. Control panel
 5. Battery charger
 6. Batteries and rack
 7. Electric governor
 8. Base mount double containment fuel tank, accessories and piping.
 9. Exhaust silencer
 10. Integral main line circuit breakers
 11. Base and isolators
 12. Annunciator panels
 13. Voltage regulator
 14. Jacket water heaters
 15. Fuel, lube oil and intake air filters
 16. System schematic diagram showing wiring interconnections with sizes and quantities.

17. Modification fact sheet giving fuel, coolant, lubricating oil, and exhaust and ventilation requirements.
18. Torsional vibration analysis for engine and generator.
19. Factory test report.
20. A start-up inspection report signed by the engine manufacturer's authorized field service representative.
21. Provide an information copy of the standard engine inspection and maintenance service contract. The contract shall be for the complete system including all auxiliary support systems.
23. Emissions
24. Remote Weatherproof Shunt Trip Operators
25. The name and location of parts and service facility which shall service equipment.
26. Parts and service as required in this section for engine and generator. Submit preventive maintenance program.
27. Manufacturer's Warranty
28. Bore, stroke, piston, speed and number of cylinders.
29. Engine displacement.
30. Temperature rise by resistance of both rotor and stator, maximum KVA and KW rating, generator efficiency, type of excitation, generator regulator and regular accessories.
31. Submit current cost of oil sampling.
32. "Too scale" Shop drawings indicating all components for exhaust muffler, exhaust piping and intake combustion air showing all parts, dimensions, and required mounting and penetration accessories.
33. Dimensions, installation, and connection requirements for generator units.
34. CFM requirements for each generator.
35. Manufacturer's recommended hours of operation between overhauls.
36. Submit generator thermal damage curve, generator current decrement curve and overcurrent protective device curve on full size 11" x 17" log-log paper. Time in seconds on Y axis and current on X axis.
37. Submit load stepping program for generator start and loading sequence.
38. Verification of the EPA Certification as required to meet emission specifications shall be submitted with the project shop drawings.

1.4 MANUFACTURER'S SERVICES

- A. Manufacturer's Services: Provide authorized equipment manufacturer's services at the jobsite. Install equipment, check the modifications, supervise start-up, and supervise testing and adjustment of the equipment. Provide two man-days to instruct the Owner's personnel in the operation and maintenance manuals prior to this instruction.

1.5 WARRANTY

- A. Warranty: The standby electric generating system components, complete genset and instrumentation panel shall be warranted by the manufacturer against defective materials and factory workmanship for a period of

five (5) years. Such defective parts shall be repaired or replaced at the manufacturer's option, free of charge for parts, labor and travel

1.6 GENERAL PROVISIONS

- A. Intent: It is the intent of these specifications to secure, for the purchaser, a diesel engine driven generator set of the latest commercial type and design as specified herein. All material and equipment shall be new and undamaged.
- B. Service: It is essential that the engine-generator supplier maintain a local parts and 168 hour/week service facility located within a 60 mile radius of jobsite. In addition, and in order not to penalize the Owner for unnecessary or prolonged periods of time for service or repairs to the emergency system, the generator set supplier must have no less than 60 percent of all engine replacement parts in his stock within the State at all times. Certified proof of this requirement shall be available from the factory distributor, and a personal inspection of the dealer's distributor's shall be made by the consulting engineer or his appointed representative to substantiate claims made by the generator set supplier. The supplier shall provide test supervision necessary for final acceptance and testing. The generator set supplier shall provide all equipment including base mount fuel tank and fuel piping. All power feeders and service entrance conductors and conduit shall be provided and completely installed. All generator control alarm and interlock wiring including conduit shall be completely provided by the Contractor. The Contractor shall be responsible for the generator set supplier and related requirements.

PART 2 - MATERIALS

2.1 MANUFACTURERS

- A. Manufacturer: The generator, and major items of auxiliary equipment, shall be manufactured in the U.S. by manufacturers currently engaged in the production of such equipment.
- B. Location and Parts: An authorized distributor maintaining a parts depot and 168 hour/week service facility shall be located within a 60 mile radius of the jobsite.
- C. Qualifications: The engine-generator manufacturer shall be an authorized full service dealer.
- D. Manufacturers: Accepted Manufacturers shall be Generac by ACF Standby Systems or Caterpillar with Generac SD300 as the basis of design.
- E. General: The units shall be manufactured in the U.S.A. and shall be the product of a firm regularly engaged in the manufacture of engine sets and shall meet the requirements of these specifications. It must be a standard model in regular production at the manufacturer's place of business. Engine, generator and control panels shall be serviced by the same supplier so that there shall be one source and one responsibility.

2.1 RATING

- A. General: The rating of the standby engine-generator shall be as listed below and based on operation when equipped with all operating accessories, including air cleaners, fans, lubricating oil pumps, fuel injection pump, and jacket water pump. The specified standby KW shall be rated for continuous electrical service during interruption of the normal utility source. The engine generator shall have the following ratings:

1. Standby KW: 80 KW/375 KW (1041 amps)
2. Engine Speed: 1,800 RPM (maximum)
3. Voltage: 120/208 volts, 3 phase 4 wire
4. Frequency: 60 hertz
5. Power Factor: .8
6. Altitude: 30 feet above sea level.
7. Engine Room Temperature: 104 degrees F. maximum, 40 degrees F. minimum.

2.2 ENGINE

- A. General: Provide an engine with the following features:

1. Full compression ignition diesel
2. Four-stroke cycle
3. Water cooled
4. Replaceable cylinder liners
5. Replaceable valve seat inserts
6. Capable of the rated output when operating on a commercially available No. 2 diesel oil (ASTM D 396).
7. Capable of extended no load operation without loss of lubricating oil.

- B. Accessories: Provide the engine with the following accessories:

1. Fuel, lube oil, and intake air filters
2. Intake air silencer, high frequency type
3. Lube oil cooler
4. Flexible fuel lines
5. Gear-driven water pump
6. Coolant and oil drain valves
7. Fuel priming pump
8. Fuel cooler for return fuel installed on radiator or as required
9. Crankcase fumes disposal system
10. Engine control wiring - multi-strand plastic insulated cable enclosed in nylon flexible slotted conduit terminated in bulkhead fittings.

2.4 SET PERFORMANCE

- A. Regulation of generator output voltage from no load to full load shall not exceed $\pm .25$ percent of rated voltage.

- B. Regulation of generator output frequency under steady state conditions shall not exceed ± 0.5 percent of rated frequency.
- C. Upon a one step application of 100 percent of rated KW, voltage drop shall not exceed 20 percent of rated voltage for no more than 1 second.
- D. Under any 3 phase, line to line, or line to neutral short circuit condition, set shall produce 250 to 500 percent of rated current and 90 to 100 percent of rated voltage for at least 10 seconds allowing sufficient time for the downstream breaker to clear a fault condition.
- E. Harmonic distortion of output wave form under full load conditions shall not exceed 5 percent.
- F. Document all tests and make available.

2.5 STARTING

- A. Starting Motor: A DC electric starting system with positive engagement drive shall be provided. The motor voltage shall be as recommended by the engine manufacturer.
- B. Automatic Control: Fully automatic generator set start stop controls in the generator switchboard shall be provided. Controls shall provide shutdown for low oil pressure, high water temperature, overspeed, overcrank, and two auxiliary contacts for activating accessory items. Controls shall include a 30 second single cranking cycle limit with lockout.
- C. Batteries: A lead acid storage battery to be used in conjunction with the electric starting system and generator control switchgear shall be provided for each engine. The batteries shall have sufficient capacity to provide for one minute total cranking time without recharging and shall be 12 hour rated. The battery shall be rated by the battery manufacturer in accordance with requirements set forth by the engine manufacturer. Provide a battery rack with bottom insert to insulate the batteries and prevent corrosion and necessary cables, clamps and replaceable connectors. Batteries shall be mounted in the building where shown and required. Wiring shall be sized as required by manufacturer for distance involved.
- D. Battery Charger: Current limiting battery charger shall be provided to automatically recharge batteries. Charger shall float at 1.4 volts per cell and equalize at 1.6 volts per cell. It shall include overload protection silicon diode full wave rectifiers, voltage surge suppressor, DC ammeter, DC voltmeter, and fused AC input. AC input voltage shall be 120 volts, single phase. Amperage output shall be no less than 10 amperes and size based on load of gear and recharge of battery in 24 hours. Charger shall be Lamarche model A46 or equal. Charger shall have auxiliary contacts to close on low voltage and N.O. AC input for connection to respective generator control cubicle in generator switchboard. Charger shall be capable of fully charging batteries during running conditions and shall be coordinated with generator provided. The chargers charging current shall be monitored within the generator controller to support remote monitoring and diagnostics. The battery charger is to be factory installed on the generator set. Due to line voltage drop concerns, a battery charger mounted in the transfer switch will be unacceptable.

2.6 GOVERNING SYSTEM

A. Governing system shall be as follows;

1. Provide a Woodward 2301, Barber Coleman or equal, electronic adjustable isochronous governor with electronic speed sensing.
2. Governor shall provide adjustable speed setting from 58 to 62 hertz and maintain the frequency within plus or minus 0.25 percent from no load to full load. Upon load change of not more than 25 percent of rated load, the governor shall re-establish stable operation in not less than one and one-half seconds. Stable operation is defined as operation at a frequency within plus or minus 0.25 percent of rated frequency.
3. The maximum change of frequency during the one and one-half second load change surging period shall not exceed 0.5 Hz.
4. After any sudden load change of not more than 25 percent of rated load, the governor shall reestablish stable operating conditions in not less than 1-1/2 seconds. Stable operation is defined as operated at a frequency that is constant within plus or minus 0.25 percent of rated frequency.
5. The maximum change of frequency during the one-half second surging period shall not exceed 0.5 Hz.
6. Governor module shall be mounted inside generator control panel.
7. The engine shall be equipped with a compatible actuator and the necessary magnetic pick-up to drive the governor.
8. All connections between the engine governor, engine and switchgear auxiliary switching points shall be made with shielded cable.
9. Governor Cable shall not be run in the same conduit with AC control of primary voltages.

B. Cylinder Liners, Pistons, and Valves: Cylinder liners, pistons, and valves shall be as follows:

1. The engine shall be provided with removable wet-type cylinder liners of close grained alloy iron, heat treated for proper hardness to obtain maximum life.
2. Pistons shall be aluminum alloy with cast iron top ring banks and chrome-faced rings.
3. Valve train shall employ replaceable valve seat inserts; alloy steel valves and cast iron guides.

C. Lubrication: Lubrication shall be as follows:

1. A gear-type lubricating oil pump shall supply oil under pressure to main bearings, crank pin bearings, pistons, timing gears, camshaft bearings and valve rocker mechanism.

2. Pistons shall be spray cooled.
3. Effective full flow lubricating oil filters shall be provided and so located that lubricating oil is continuously filtered except during periods when oil is by-passed to protect vital parts such as when filters are clogged.
4. Replacement resin impregnated cellulose type filter elements shall be accessible and easily removable. Filter system shall be equipped with a spring-loaded bypass valve as an insurance against stoppage of lubricating oil circulation in event the filters become clogged.
5. A suitable water-cooled, engine-mounted lubricating oil cooler shall be provided. The diesel oil sump drain shall be brought to the outside of the set for ease of changing oil.
- D. Air Cleaners: One or more engine-mounted dry type air cleaners of sufficient capacity to protect working parts of the engine from dust and grit shall be provided.
- E. Fuel System: Fuel system shall be as follows:
 1. Injection pumps and injection valves shall not require adjustment in service. The engine shall have an individual mechanical injection valve for each cylinder, any one of which may be removed and replaced from parts stock.
 2. Fuel injection pump shall be positive action, constant-stroke pumps, actuated by a cam driven by gears from the engine crankshaft. Fuel lines between injection pump and valves shall be heavy seamless tubing, and, to eliminate irregularity of fuel injections, shall be of the same length for all cylinders.
 3. Fuel system shall be equipped with replaceable fuel filter elements which may be easily removed without breaking any fuel line connections or disturbing the fuel pumps or any other part of the engine. Fuel filter shall include fuel pressure gauge, bypass valve (normally closed), manual shutoff valve.
 4. All fuel filters shall be conveniently located in one accessible housing, ahead of injection pump so that fuel shall have been thoroughly filtered before it reaches the pump. No screens or filters requiring cleaning or replacement shall be used in injection pump or injection valve assemblies.
 5. Engine shall be equipped with a built-in gear-type engine-driven fuel transfer pump, capable of lifting fuel against a head of 3 feet, for supplying fuel through the filters to the injection pump at constant pressure.
 6. Provide a water separator on the engine just ahead of the fuel filters constructed of heat-resistant glass, with aluminum-perforated baffle for viewing amount of water contained.
 7. Provide pre-engineered, skid mounted FDEP approved base mount double

containment diesel fuel tank with rupture alarms. Provide for on-site fuel load for 550 gallons for 21 hours of run time at full load. Tank must be constructed in accordance NFPA 30, UL-142 and UL-80. Tank shall have a high level alarm, low level alarm and high level automatic shutoff and shall be capable of sending off-site electronic alarms. Maximum dimensions of fuel tank shall be 158" L x 58" W x 30" H . Tank shall be provided with EQ numbers.

8. Contractor is responsible to perform breach integrity as required by NFPA 30 2015 edition.

F. Jacket Water Heater: Jacket water heater shall be as follows;

1. Provide a unit-mounted thermal circulation-type water heater incorporating a self-contained thermostatic switch, controlled by the exit coolant temperature from the heater to maintain engine jacket coolant to 90 degree F.
2. The heater shall be single phase, 60 Hz, 208 volts. Heater shall be Chromalox, or Kim-Hotstart.
3. Provide hand valves in the heater hoses to facilitate changing heating elements without draining the entire cooling system.

G. Engine Instrument Panel and Safety Switches.

1. Engine Instrument Panel: Provide an engine-mounted instrument panel with gauges for items in the following table.

2. Safety Switches: Provide devices for indication and control of the items in the following table requiring pre-alarm and shutdown:

Indicator Function (at Battery Voltage)	CV	S	RA
(a) Overcrank		X	X
(b) Low Water Temp. < 70° F (21° C)		X	X
(c) High Engine Temp Prealarm		X	X
(d) High Engine Temperature		X	X
(e) Low Lube Oil Pressure Prealarm		X	X
(f) Low Lube Oil Pressure		X	X
(g) Overspeed		X	X
(h) Low Fuel Tank (@ 12 hrs. fuel remaining)		X	X
(i) EPS Supplying Load		X	X
(j) Control or Test Switch Not in Auto. Position		X	X
(k) Battery Charger Malfunctioning		X	X
(l) Low Voltage in Battery		X	
(m) Lamp Test		X	
(n) Contacts for Local & Remote Com. Alarm		X	X*
(o) Audible Alarm Silencing Switch			X
(p) Low Starting Air Pressure		X	
(q) Low Starting Hydraulic Pressure		X	
(r) Air Shutdown Damper when used		X	X
(s) Remote Emergency Stop Weatherproof		X	
KEY: CV Control panel-mtd. visual indication RA Remote Audible S Shutdown of EPS X Required * Remote common for l, m, p, q, & s			

H. Exhaust System: The exhaust system shall be as follows:

1. Offset exhaust system shall consist of an internally insulated critical silencer, manufactured by GT exhaust or equal offset flexible exhaust fitting. Provide Offset exhaust piping, pipe insulation, and offset mounting hardware are custom fabricated and shall be provided and installed by the contractor. Install muffler and exhaust piping as required per manufacturer for indoor applications. Pipe size to be coordinated to allow for any backpressure issues.
2. Provide a critical type silencer constructed of milled steel. Silencer shall reduce noise to 75 dba at 25 feet. Provide offset brackets, companion flanges, gaskets, and fasteners.
3. Provide Type 316 stainless steel bellows-type offset flexible exhaust fitting no more than 18 inches long.
4. Provide vertical and horizontal discharge piping including tailpipe and weatherproof thru-wall weatherproof wall thimble. Undercut at 45 degrees and cover with 80 percent expanded galvanized metal bird screen by installing contractor.
5. Provide insulated exhaust system consisting of adapters, elbows, lined bellows, piping, supports, drain tees, and support assemblies.
6. Pitch horizontal runs of exhaust pipe away from the engine. Provide condensate traps with petcocks or valves at low spots in the exhaust system.
7. Inlet and outlet size shall be as required by engine manufacturer.
7. Inlet and outlet size shall be as required by engine manufacturer.
8. Provide rain cap and bird screen on end of tailpipe.

2.7 EXHAUST EMISSIONS

- A. General: To maintain environmental quality, the engine shall be EPA Certified from the factory according to the United States Environmental Protection Agency.

Verification of the EPA Certification as required to meet emission specifications shall be submitted with the project shop drawings.

2.8 GENERATOR

- A. General: Provide the following:

- 1 The random wound generator shall be a 3 phase, 60 Hz, 120/208volt as noted on drawings, insulated, single-bearing, drip-proof, rotating field, synchronous type, with 3 phase brushless PMG exciter.
 - 2 Provide Class H insulation limited to 125 degrees C rise.
 - 3 Provide 100 percent epoxy varnish impregnation and a coat of epoxy asphalt insulating material to increase resistance to abrasive dust or sand, high humidity, and light acidic, oil, or salt-laden atmospheres, as well as prevent fungus growth.
- B. SCR Equipment: Generator shall be designed for operation of SCR type equipment.
- C. Wave Form: The wave form deviation factor of the line-to-line voltage at no load and balanced rated load at 0.8 power factor not to exceed 4 percent. The rms of all harmonics shall be less than 2 percent and that of any one harmonic less than 1 percent at full rated load. TIF shall be under 50.
- D. Transient Dip: The transient dip shall not be greater than 20 percent of rated voltage when full load at rated power factor within 5 cycles is applied to the generator.
- E. Voltage Regulator: Provide a static type voltage regulator to maintain a constant and stable generator output voltage within plus or minus 0.5 percent of nominal for all steady-state loads from no load to full load with isochronous speed control and plus or minus 2 percent speed droop operation. A 5 percent variation in frequency and the effects of field heating will not affect the unit's regulation. Provide stability and voltage range adjustments.
- F. Fault Current: Provide permanent magnet generator boost to provide a minimum of 300 percent of fault current for 10 seconds.

2.9 STRUCTURAL STEEL BASE

- A. Base: Isolate the structural steel base from the engine with isolators with neoprene-jacketed pre-compressed molded fiberglass noise isolation pads, steel load plate, built-in leveling bolt, welded steel or cast housing, and high deflection steel springs.
- B. Isolators: Isolators shall be Peabody Noise Control, Inc.; Kinetics brand, Type SM; Norfund or Dynamics Corporation or equal.

2.10 COOLING SYSTEM - ENGINE MOUNTED RADIATOR

- A. Radiator: Provide an engine-mounted radiator with blower-type fan sized to maintain rated full load continuously at the specified maximum ambient temperature. Fan rpm shall not exceed 819 rpm. Provide complete fabricated galvanized sheet metal exhaust connection and cowling including overhead metal insulated exhaust duct with a rigid and weatherproof connection at the exhaust exit on the exterior wall. This is to be provided by the Contractor.

- B. Coolant Switch: Equip the radiator with a 1 inch wide duct adapter flange and low coolant level switch with 1 N.O. and 1 N.C. contact.
- C. Airflow: Airflow restriction from the radiator shall not exceed 0.50 inch water.
- D. Fluid: Fill the engine cooling system with a solution of 30 percent by volume ethylene glycol with rust inhibitor.

2.11 GENERATOR CONTROL PANEL

- A. General: Provide a NEMA 1, vibration isolated, dead front, 12 gauge steel control panel with lockable hinged cover. Mount and wire the control panel to the engine-generator set. The panel shall include the following equipment:
 - 1 Voltmeter, 1 percent accuracy with 3 phase fuse protection digital type to read true rms.
 - 2 Ammeter, 1 percent accuracy, digital type to read true rms.
 - 3 One ammeter and one voltmeter phase selector switch.
 - 4 Frequency meter, 1 percent digital type.
 - 5 Running time meter.
 - 6 Instrument transformers: Automatic starting controls, cycle crank.
 - 7 Voltage level adjustment rheostat, minus 25 to plus 10 percent.
 - 8 Dry contacts for remote alarms wired to terminal strips.
 - a. Fault indicator lights with press to test feature for low oil pressure, high coolant temperature, low coolant level, overspeed, and overcrank.
 - 9 Visual alarm indicators for impending shutdown from oil pressure and high coolant temperature.
 - 10 Visual alarm indicators for low fuel level and low coolant temperature.
 - 11 Three-position function switch marked "manual", "off/reset", and "auto".
 - 12 Emergency engine stop pushbutton.
 - 13 Panel illumination lights and switch.
- B. Components: Pilot lights and pushbuttons shall be standard duty type.

- C. Devices: Provide relays and timing devices with clear polycarbonate dust covers. Devices shall be plug-in type with hold-down spring retainers. Output contacts shall be rated 10 amperes at 24 volt dc.
- D. Controls: Provide engraved or etched nameplates to show position of switches and function of pilot lights, pushbuttons, and meters.
- E. Provide fully automatic set start-stop controls in the generator panel. Controls shall operate as follows;
 - 1 With switch in automatic position closure of a set of external contacts or switch in manual position, the engine shall automatically crank.
 - 2 An adjustable cranking limiter shall allow from 2 to 5 cycles of 30 seconds continuous cranking.
 - a. If the engine fails to start, starting circuit shall be locked out and the overcrank light illuminated.
 - 3 The engine will shut down when operating in the automatic mode and the remote engine run contact open.
 - 4 Initiation of any safety shutdown shall immediately stop the engine and light the appropriate light.
 - 5 Upon correction of the fault, the shutoff system shall be made operable by moving the function switch to off/reset and then back to the "auto" position.
 - 6. Provide all relays, interface components, wiring and installation for a complete load starting and generator set load stepping programming. Include up to (6) distinct load steps with separate time delay control relays for each step. All wiring, conduit and load bank system testing shall be included with this requirement for a complete and functional load stepping systems.
- F. Main Line Circuit Breakers: Provide internal main line circuit breakers as follows;
 - 1 Provide (1) one integral 100% rated 3-pole, 600-volt electronic main line solid state circuit breakers sized per drawings. Circuit breakers shall have permanent plastic color coded nameplates indicating the load served. Solid state circuit breakers shall have adjustable settings for long-time, short-time instantaneous, long-time delay and heat-time delay. Provide (DC – shunt trips based on 12 vdc batteries) shunt trip coil type circuit breakers.
 - 2. Integral circuit breakers shall be capable of adjustable settings in order to provide complete circuit breaker tripping coordination.
 - 3. Install on the generator in an enclosure to function as a UL listed load circuit interrupting and protection device.
 - 4. Circuit breakers shall be trip free of the handle.
 - 5. The handle position, or a luminescent flag, shall indicate "off", "on", or "tripped" breaker positions.

6. The trip unit for each pole shall have elements providing inverse time delay during overload conditions and instantaneous magnetic tripping for short-circuit protection. Breaker shall also include an integral 24 volt D.C. shunt trip for remote trip.
7. Insulated neutral terminals and a ground terminal shall be provided and marked.
8. Circuit breakers shall meet standards established by UL, NEMA, and NEC.
9. Do not use generator exciter field circuit breakers.
10. Manufacturer: General Electric, Square D, Westinghouse.

PART 3 - EXECUTION- EMERGENCY GENERATOR - MISCELLANEOUS REQUIREMENTS

3.1 GENERAL

- A. Miscellaneous Requirements: Provide the following:
 1. Equipment nameplate.
 2. Operating manual (5 copies).
 3. Parts list (5 copies).
 4. Special tools (as required).
 5. Lubricants (6 months supply).
 6. As-built shop drawings (5 sets).
 7. Services of a Manufacturer's Representative, minimum five (5) days.
 8. Start sequence staging.

3.2 PREVENTIVE MAINTENANCE PROGRAM REQUIREMENT

- A. General: The manufacturer of the Power Generation System equipment shall develop a computerized preventative maintenance program. Specific recommendations for actual equipment application shall be made for a computerized program based on operating hours and/or elapsed time. The preventative maintenance recommendations shall be submitted with the shop drawings.

3.3 SYSTEM SERVICE CONTRACT

- A. General: The supplier of the power system must provide a copy of and make available to the Owner his standard service contract which, at the Owner's option, may be accepted or refused. This contract shall accompany any documents, drawings, catalog cuts, specification sheet, and wiring or outline drawings, etc. submitted for acceptance to the designing engineer.

3.4 REMOTE ANNUNCIATION

- A. General: Provide all necessary and required remote emergency and standby power status indicators, relays, switches, start/stop controls, supervision devices, manual start and transfer features and all associated wiring for remote annunciation and control for the generator and transfer functions per NFPA 110 including but not limited the following:
1. Normal power on/off indicators.
 2. Generator running indicators.
 3. Pre-alarm trouble on
 4. Generator trouble shutdown.
 5. Emergency system operating.
 6. Diesel tank low level.
 7. Diesel tank rupture.
 8. Provide communication cable for annunciator operation.
 9. Remote and Manual start /stop
 10. Supervision devices
 11. Manual transfer feature

3.5 FUEL (BY CONTRACTOR)

- A. General: Fill the tank with No. 2 Diesel fuel oil meeting ASTM D 396. After field testing is complete, the Contractor shall include all costs of refilling the fuel tank for a complete project. This requirement is by the Contractor.

- B. SUB-BASE FUEL TANK:

Provide a UL listed Double Wall diesel fuel storage tank. The fuel tank shall be an integral part of the enclosure/generator mounting frame and shall be installed beneath the interior floor level. Fuel tank shall have a capacity of no less than the 550 gallons required to provide 21 hours of run time under 100% full load conditions. Fuel tank provided shall comply with and be constructed in accordance with the requirements of Underwriters Laboratories UL-142 "Special Purpose Protected Secondary Containment Generator Base Tank"; N.F.P.A. 30, 37 & 110; Florida Department of Environmental Protection (FDEP) and the Steel Tank Institute. Fuel tank venting is to be provided by this contractor and shall be in compliance with NFPA and UL. Maximum dimensions of fuel tank shall be 158" Long and 58" Wide and 30" tall. Tank shall be provided with EQ numbers.

Complete assembly shall be manufactured using minimum 10 gauge sheet steel for the inner tank and ¼" Steel for outer tanks. Fuel tank and containment basin are to be leak tested at 3-PSI air as outlined in UL-142 standards. The interstitial space shall be monitored using a float type level switch and shall indicate the presences of fuel in the annular space by use of normally open contacts that are to be wired back to the generator set control panel for visual/audible indication.

Fuel tank provided shall have the following devices but by no means be limited to those as specified. A

2" Manual fuel fill cap, mechanical fuel level gauge, overspill containment around fuel fill, high level alarm set at 90% of tank capacity, low level alarm set at 40% of tank capacity, rupture basin alarm with normally open contacts, two (2) spare 2" NPT ports with installed plug, fuel supply and return ports with full length pick-up tubes. A foot or check valve shall be installed on the generator supply to prevent loss of prime during idle conditions. A rectangular double-walled electrical stub-up area is to be provided and located directly under the generator circuit breaker to provide a pass-through for field installation of electrical load conductors.

Vibration isolator mounts shall be each located above an internal tank baffles and securely welded to the top plate to ensure adequate load support. Isolator mounting plates are to be 1" thick steel plate, tapped for isolator bolting. Tanks requiring beams across the top to transfer the generator weight to the outer rails for support will not be acceptable.

The entire steel fuel tank, basin and interior floor shall be coated with a wear resistant, high quality anti-corrosive material and topcoat. Four-point lifting provisions shall be provided on the enclosure base tank and strategically located based on the center of gravity for the specific unit to ensure a balanced even lift during rigging. Lifting provisions located on the fuel base tank shall have capacity suitable for rigging the entire assembly.

Field anchoring of the tank to the concrete pad will be accomplished with anchor plates spaced approximately on 24" centers and provided by the enclosure manufacturer with the frame and shipped loose with the enclosure package. Appropriate 3/4" anchor bolts will be provided by installing contractor.

Closed top diked, open top diked and single wall fuel tanks shall not be allowed.

For fuel tanks over 24" in height at least two set of non-corrosive stairs with handrail shall be provided by the manufacturer for installation by the contractor.

Manufacturer to provide exact warranty to match the generator.

3.6 CONCRETE FOUNDATIONS

- A. Provide two section foundation for generator set in accordance with set manufactures recommendations. Concrete pads shall be at least 6 inches thick and shall extend 4 to 6 inches beyond the overall footprint of the set mounting base or fuel tank whichever is larger.
- B. The entire generator assembly shall be mounted on equipment Isolation pads spaced equally around the outer perimeter of the assembly. Provide up to 12 Isolation pads. Pads shall be Kinetics or equal and sized for total weight of assembly.

3.7 STARTUP

- A. Initial: On completion of the installation, the initial startup shall be performed by a factory-trained service representative of the engine supplier, who shall thoroughly inspect, operate, test and adjust the

equipment.

- B. Provisions: The inspection shall include the soundness of all parts, completeness of all details, and proper operation of all components with special emphasis on safety devices, correctness of settings, proper alignments, and correct phase rotation to match other sources.
- C. Tests: Field tests shall include the following:
 - 1. Simulate power failure by tripping the main breaker and demonstrate complete manual and automatic start, load, unload, and stop sequence of the engine-generator.
 - 2. Conduct a two-hour run with generator operating, utilizing maximum available load. If available load is less than 100% of the generator's rating, then furnish and add loads to obtain 100% generator loading.
 - 3. Conduct a block loading test in accordance with NFPA-110.
 - 4. Contractor shall provide all contact, required correspondence and required attendance for State permitting documentation to the State or Local inspector as required for all required licensure, inspections, permitting and permanent tagging of all fuel tanks and connections.

Department of Environmental Protection Contact:

Glen Becker, Senior Environmental Specialist
Environmental Protection Division
Storage Tanks Compliance
800 Mercy Drive, Suite 4
Orlando, FL 32808
Office: 407-836-1453
glen.becker@ocfl.net

3.8 SYSTEM SERVICE CONTRACT

- A. General: The supplier for the engine-generator shall provide a copy of his standard engine-generator inspection and maintenance service contract for Owner review.

END OF SECTION

SECTION 263600 - AUTOMATIC TRANSFER SWITCH**PART 1 – GENERAL****1.1 RELATED DOCUMENTS**

- A. General: Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.

1.2 DESCRIPTION

- A. General: Provide automatic transfer switches of the size, quantity, number of poles, amperage, voltage and withstand ratings as shown on the contract drawings and as specified herein.
- B. Description: Using a NEMA 1 enclosures, the switches shall automatically transfer the load to the generator during normal power outages. The switches shall be fully rated, electrically operated, mechanically held unit with both electrical and mechanical interlocks to prevent simultaneous energizing of both sides. Switch shall be a 600-volt class.

1.3 QUALITY ASSURANCE

- A. Manufacturer Requirements: Firms regularly engaged in manufacture of automatic transfer switches, of types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. The transfer switch shall be completely compatible with the emergency generator System. The Acceptable manufacturers are Kohler MPAC1500 or ASCO 7000 series
- B. Standards: Comply With The Following Standards:
 - 1. UL-1008
 - a. As a precondition for acceptance, transfer switch, complete with timers relays and accessories shall be listed by Underwriters Laboratories, Inc. in their Electrical Construction Materials Catalog, and accepted for use on emergency systems.
 - b. When conducting temperature rise tests to Paragraph 99 of UL-1008 the manufacturer shall include post-endurance temperature rise tests to verify the ability of the transfer switch to carry full rated current after completing the overload and endurance tests.
 - c. Produce UL 1008 closing and withstand ratings for 3 cycles at 208 volts. Submitted test reports from an independent testing laboratory to verify the identical samples have been subject to three phase short circuit current at voltage indicated on drawings, for a minimum of 3 cycle's duration, without contact damage or contact welding and without the use of current limiting fuse protection.

1.4 SUBMITTALS

- A. Shop Drawings: Provide all equipment cabinet dimensions and wiring diagrams.
- B. Product Data: Provide all applicable options, accessories, and interrupting or withstanding current ratings. Provide all electrical characteristics and data to show compliance with these specifications.
- C. Testing: Provide test results from UL 1008 as listed above.

1.5 PRODUCT HANDLING

- A. Equipment Storage: The Contractor shall store items provided under this specifications until time of installation. Such storage shall meet the requirements of the system supplier and be accepted by the Engineer. The stored equipment shall not be delivered to the site until it is to be installed.
- B. Protection: Use all means necessary to protect the materials of this section before, during and after installation and to protect the installed work and materials from the activities of all other trades.
- C. Replacement: In the event of damage, immediately make all repairs and replacements necessary to the acceptance of the Engineer and at no cost to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Type: Provide one 3-pole, 4-wire, 42KAIC rated, solid neutral, 3-phase, 120/208volt, open transition with in-phase monitor weatherproof Nema 3r, automatic transfer switches sized as shown on plans, with full load current and voltage rating as shown, 60 Hz normal and emergency.
- B. Load Types: The transfer switch shall be capable of switching all classes of load, and shall be rated for continuous duty when installed in an enclosure that is constructed in accordance with Underwriters Laboratories, Inc., Standard UL-1008.
- C. Accessories: All relays, timers, control wiring and accessories to be front accessible.

2.2 COMPONENTS

- A. Features: Provide the following transfer switches with the following features:
 - 1. The transfer switch shall be double throw, actuated by a single electrical operator momentarily energized; and mechanically connected to the transfer mechanism by a simple over center type linkage with a total transfer time not to exceed 1/6 of a second.

2. The mechanism shall be a high speed actuator, capable of transferring successfully in either direction with 75 percent of rated voltage applied to the switch terminals.
 3. Circuit breaker switches are not acceptable.
 4. Mechanical interlocking of transfer switches to prevent unintended interconnection of the normal and alternate sources of power.
 5. A means of safe manual operation of the transfer switch.
 6. The transfer switch shall have a time delay feature for the neutral position.
- B. Main Contacts: The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be fully rated, arc quenching, mechanically locked in both the normal and emergency positions without the use of hooks, latches, magnet, or springs and shall be renewable silver-tungsten alloy protected by arcing contacts, with magnetic blowouts on each pole. Contacts shall be able to withstand high fault current levels without contact damage or separation. Parallel main contacts are not acceptable.
- C. Exercise Timer: Include an exerciser with the transfer switches for exercising the generator in loaded or unloaded condition, with a cycle of 1, 7, 14, 28, or 365 days for a period adjustable from a minimum of 20 minute intervals to 10 hours.
- D. Engine Start Delay: Time delay to override momentary normal source power outages to delay engine start signal and transfer switch operation. Adjustable 0.5 to 6 seconds, factory set at 3 seconds.
- E. Load Test Switch: Load test switch to simulate normal power failure. (Maintained type).
- F. Contact Failure indicators: Contact to close on failure of normal source to interface with data acquisition panel. Contact to open on failure of normal source to initiate customer functions.
- G. Pilot lights: Green pilot light on the cabinet door to indicate the main switch in normal position. Red pilot light on the cabinet door to indicate the main switch in emergency position. All pilot lights to have push to test function and shall be Weatherproof.
- H. Auxiliary Contacts: Provide 2 sets of auxiliary contacts closed in the normal position. Provide 2 sets of auxiliary contacts in the closed in emergency position.
- I. Additional Contacts: Four sets of relay contacts shall be provided to open and close upon loss of the normal power supply.
- 2.3 OPERATION

- A. Low Voltage: Provide engine starting contacts in transfer switches to start the generating plant if any ungrounded phase of the normal source drops below 75 percent of rated voltage, after a non-adjustable time delay period of 1 to 6 seconds, to allow for momentary dips.
- B. Transfer: The transfer switch shall transfer to emergency as soon as the generator source voltage and frequency have reached 90 percent of rated values.
- C. Stabilization; After restoration of normal power on all phases to 90 to 95 percent of rated voltage, adjustable time delay period of 0 to 60 minutes shall delay transfer to normal power until it has had time to stabilize. If the emergency power source shall fail during the time delay period, the time delay shall be by-passed, and the switch shall return immediately to the normal source.
- D. Generator No-Load Operation: Whenever the switch has retransferred to normal, the engine-generator shall be allowed to operate at no load for an adjustable period of time (0 to 60 minutes) to allow it to cool before shut-down.
- E. Test Switch: The transfer switch shall include a test switch to simulate normal power failure with actual load transfer.
- F. Time Delays
 - 1. The control module shall include four time delays that are fully field-adjustable by keypad or keyboard in increments of 1 second over the entire range.
 - 2. Adjustments and viewing of the time delay values shall be accessible when the enclosure door is closed.
 - 3. Microprocessor controller shall indicate time relay in progress.
 - 4. Required Time Delays
 - a. Time delay for engine start to delay initiation of transfer for momentary source outages: Range 0-6 seconds. Factory set at 5 seconds.
 - b. Time delay for transfer to emergency: Range 0-5 minutes. Factory set at 5 seconds.
 - c. Time delay for transfer back to normal: Range 0-60 minutes. Factory set at 5 seconds.
 - d. Time delay for engine cool-down: Range 0-60 minutes. Factory set at 5 seconds.
 - 5. Input values outside the allowable parameters shall cause a "range error" message to be displayed.
- G. The user shall have the ability to manually program an engine start and run for a period of up to 10 hours in the loaded or unloaded mode of operation. The time delay transfer to emergency and/or normal may be bypassed during the run period. A numeric indication shall be displayed of the run time remaining in hours and minutes.

The run period may be stopped at any time with a single keystroke. After the run period has stopped, the engine shall run unloaded for the cool down time.

- H. User terminals shall be available to connect a normally closed contact that, when opened, signals the control module to start and transfer load to the engine-generator. Closing these contacts shall initiate a retransfer and engine cool down sequence. The load shall be transferred to an available utility source immediately if the generator source should fail.
- I. The following features shall be built into the control module logic. These features shall be enabled at the factory or in the field by installing an insulated program jumper provided by the vendor as standard.
 - 1. Anti-single phasing protection shall detect regenerative voltage as a failed source condition.
 - 2. In-phase monitoring shall continuously monitor the contactor transfer times, source voltage, frequency and phase angle to provide a self-adjusting, zero crossing contactor transfer signal.
 - 3. Manual operation override shall function to bypass any manual switch accessories if the source to which the transfer switch is positioned fails. This program jumper shall be factory installed.
 - 4. All phases of normal and all or single phases of emergency shall be monitored for overvoltage and single phase of normal and emergency for over- and under-frequency. The values shall be programmed with the enclosure door closed.
- J. Status Indicators-Control shall be capable of being manipulated from an in cover WP access portal.
 - 1. Light-emitting diodes shall indicate the status of the Contactor Position.
 - 2. System Status
 - a. Transfer Switch Position Sensing Fault
 - b. Transfer Switch Fail to Transfer
Internal Control Module Fault
Manual Transfer Operation
 - c. Programming Switch Not In Off
 - d. The system status messages shall also be shown on the alphanumeric display.
 - 3. Accessory Active
 - Plant Exerciser
 - In-Phase Monitor
 - Load Shed

Area Protection

A lamp test push button shall light all light-emitting diodes.

- K. The control module shall have a three-position, key-operated, programming control switch. The key shall be removable in any position. The positions shall be:
 - 1. Off--Allows all enabled accessories to be monitored only. Settings cannot be changed while in this position.
 - 2. Local--Allows all enabled accessory settings to be changed by local keypad entry.
 - 3. Remote--Allows all enabled accessories to be altered via the remote communications port.
- L. A momentary-type test switch shall be provided to simulate a normal source failure.
- M. The transfer switch shall be able to control up to 10 isolated form C auxiliary contacts for indication of switch position and source availability.
- N. The transfer switch shall have load-shed and sequencing capability to allow up to nine selected loads to be disconnected prior to transfer in either direction. It shall be possible to vary the time sequence for reenergizing of the nine loads.
- O. A set of gold-flashed contacts rated 10 amps, 28VDC shall be provided for a low-voltage engine start signal when the normal source fails.

PART 3 - EXECUTION

3.1 CONDITIONS

- A. Inspection: Prior to performing the work required by this section, carefully inspect the installed materials and equipment of all other trades and verify that the project has progressed to a point where this inspection may properly begin.
- B. Verification: Verify that all equipment provided under this section of the specification may be installed in accordance with all pertinent codes and regulations, the original design, and the referenced standards.
- C. Discrepancies: If any discrepancies are found, immediately notify the Engineer. Do not proceed with the installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.2 CONNECTIONS

- A. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements

are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std.
486A and 486B.

END OF SECTION

SECTION 264113 - LIGHTNING PROTECTION**PART 1 - GENERAL****1.1 DESCRIPTION****A. Description of Systems:**

1. A Lightning Protection System shall be placed on the structure by experienced installers in compliance with provisions of Code for Lightning Protection Systems as adopted by the National Fire Protection Association and Underwriters' Laboratories. Intent of the lightning protection systems shall be to protect the new building against damage by lightning. All equipment to that result shall be included whether or not specifically called for herein. Installers shall be LPI (Lightning Protection Institute) certified, master and Journeyman in accordance with LPI Standards or of equal qualifications as approved by the Owner or the Owner's authorized representative. A U.L. Master Label for the system and a witness of grounding form, similar to that required by LPI (Form 175-A), shall be required.
2. Materials shall comply in weight, size and composition with the requirements of Underwriters' Laboratories and the National Fire Protection Code relating to this type of installation, and shall be U.L. Labeled.
3. Contractor shall be required to pull a permit for their work and provide a complete package of permit, drawings, specifications and details for a complete turnkey system, including but not limited to:
 - a. Air terminals
 - b. Bonding plates
 - c. Conductors
 - d. Connectors
 - e. Fasteners
 - f. Grounding plates
 - g. Grounding rods
 - h. Rod clamps
 - i. Splicers
 - j. Fittings
 - k. Test wells.

1.2 SUBMITTALS**A. Shop Drawings and Product Data:**

1. Shop Drawings: Shop drawings shall be submitted for approval before any work is started. Drawings shall include full "to scale" layout of cabling and air terminal points, and connections.
2. Product Data: Product Data shall be submitted on all equipment to show compliance with this section of the specifications and shall include manufacturer's written recommendations for installation. Information shall be submitted for approval before any work is started.

PART 2 - PRODUCTS AND INSTALLATION

2.1 AIR TERMINALS

- A. Air Terminals shall be solid aluminum; to be coordinated with the building flashing materials; and shall have proper base support for surface on which they are attached, and shall be securely anchored to this surface. Terminals shall project a minimum of 12" above top of object to which attached.

2.2 CONDUCTORS

- A. Roof conductors shall consist of aluminum; to be coordinated with the building flashing materials, complying with the weight and construction requirements of the Code, and shall be coursed to interconnect with air terminals, and in general, provide a two-way minimum path to ground. The angle of any turn shall not exceed 90 degrees, and shall provide an approximately horizontal or downward course. Down conductors shall be copper, and shall be installed in concealed PVC conduit and concealed within the structure. Approved bi-metal transitions from aluminum roof conductors to copper down conductors shall be provided where aluminum building flashing is used.

2.3 FASTENERS

- A. Conductor fasteners shall be of the same material as the conductor, having ample strength to support conductor. Where fasteners are to be mounted in masonry or structural work, they shall be furnished to the Masonry or Structural Contractor so they may be installed during construction of the project.

2.4 GROUND CONNECTIONS

- A. Ground connections shall be made in accordance with requirements of all applicable codes. Ground rods shall be placed in a minimum of two (2) feet from building foundations. In addition to the above requirements additional grounds, one down conductor of each two-path system shall be connected to metallic water piping system with approved water pipe type strap connector. All ground rods shall be a minimum of 5/8" X 50'0" long (sectional) copper-weld type.
- B. Provide equipment grounding and bonding connections sufficiently tight to assure permanent and effective grounds and bonds.
- C. Grounded metal bodies within the bonding distance determined by the bonding distance requirements of NFPA shall be bonded to the system using bonding conductors and fittings in accordance with code requirements.
- D. Underground metallic piping entering the building shall be bonded to the nearest down conductor or ground electrode.
- E. Bond to metallic water service, underground metallic piping systems and the building electrical grounding electrode system as shown and as required by codes.

- F. Bond to metal bodies of conductance on roof with main size conductors as shown and as required by codes. These bonds include, but are not limited to, exhaust fans and stacks, vents, handrails, ladders, conduits, exhaust fans, HVAC / RTU units, antennas, roof mounted lighting standards, etc. or any large metal body subject to direct stroke or which exceeds the height of adjacent air terminals.
- G. Bond to metal bodies of inductance located within 6'-0" of main conductor or other bonded object with approved secondary bonding conductor as shown and as required by codes. Such objects include, but are not limited to: flashing, metal coping caps, gravel guards, fascias, roof drains, downspouts, interior ducts, exhaust fans, HVAC units, boxes, conduits, boxes, machinery or piping, etc., or in general, any isolated body at or below the roof subject to inductance and within 6'-0" of the system.

2.5 INSTALLATION

- A. Installation shall be made in an inconspicuous manner with conductors coursed to conceal equipment as much as possible. Down conductors shall be concealed within the structure, and shall be run in 1" PVC concealed conduit. All metallic equipment within 6 feet of any lightning conductor shall be bonded to conductor. System shall also be tied to the main service electrical grounding electrode conductor system.

2.6 EQUIPMENT

- A. Equipment shall be as manufactured by Thompson Lightning Protection, Inc. as specified; or approved substitutions as manufactured by: Independent Protection Company, Inc., Heary Bros. Lightning Protection or Harger (premium lines).

2.7 CORROSION PROTECTION

- A. Use no combination of materials that may form an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture, unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist that would cause deterioration or corrosion of conductors, use conductors with suitable protective coatings.

2.8 FIELD QUALITY CONTROL

- A. Provide advance notice of at least 24 hours to the Owner's Authorized Representative before concealing lightning protection system work.
- B. Location of all devices and equipment shall be coordinated with all trade contractors and shop drawings prior to submittal of shop drawings.
- C. Coordinate installation with other trades to avoid conflicts.
- D. During construction, inspection and testing shall be made to assure a low resistance path throughout the system. Upon completion, the air terminals shall be tested for resistance to the grounding electrode system. Any air terminal which has more than 5 ohms resistance to ground shall be connected by additional approved means to reduce the resistance to 5 ohms or less.

- E. The Contractor shall be responsible for inspecting and testing the system and shall furnish all materials, instruments and labor requirement to perform same. Owner's Authorized Representative shall witness the final test.

PART 3 – EXECUTION (Not applicable)

END OF SECTION

SECTION 265100 - LIGHTING MATERIALS AND METHODS**PART 1 - GENERAL****1.1 SCOPE:**

- A. Lighting fixtures shall be furnished and installed as shown on the drawings and as herein specified in attached schedules.

PART 2 - PRODUCTS**2.1 FIXTURES:**

- A. Lighting fixtures shall be furnished as shown on drawings and as shown within the Lighting Fixture Schedule and as indicated on the Interior design drawings. It shall specifically be the responsibility of the Contractor to verify the exact type ceiling and or recessing depth of all fixtures and to furnish the exact and proper mounting trims and all accessories required of the specified and/or approved fixtures for the ceiling and application that the fixture is to be installed. All Lighting fixtures shall be provided with a UL Listing, joiner plates, escutcheons, UL fixture tenting, recessed fixture IC ratings, mounting brackets, poles, slip-fitters, swivel ball aligners, dimming ballasts, emergency battery ballasts, end caps, retaining clips, drywall plaster frames, low temperature ballasts or drivers, housings, concrete bases, poles, structural supporting materials and all other accessories required for a complete fixture installation.
- B. Fluorescent Fixtures:
 - 1. Shall be designed to function with the ballast installed, without interruption, when operating in a room ambient temperature of 80°F. and a plenum ambient temperature of 100°F.
 - 2. Shall be equipped with energy saving ballasts unless specified or noted otherwise.

2.2 FLUORESCENT BALLASTS:

- A. Shall be approved ETL and have UL and CBM labels.
- B. Shall be high power factor.
- C. Shall be sound rated "A".
- D. Energy efficient electronic ballasts shall be CBM rated full light output, for use with single or double lamps as required and shall be electronic type with less than 10 percent total harmonic distortion.

2.3 LAMPS:

- A. All fixtures shall be equipped with lamps unless otherwise noted. Lamps shall be installed new, immediately prior to final inspection, and shall not be used for construction.
- B. Lamps shall be of size and type as shown in schedules or on drawings.

2.4 SCHEDULES:

- A. See schedule of lighting fixtures on drawings.

2.5 FIXTURE SCHEDULE NOTES:

- A. Fixture catalog number represents basic luminary size, type, quality and configuration. Accessories shall be furnished with each unit as required for a complete finished installation. Basic accessories shall include, but are not limited to, the following:
 - 1. Ball aligners, joining plates, end caps, retaining clips, emergency battery ballasts etc.
 - 2. Trims for recessed and surface mounted fixtures to wood, concrete pre-stress or hollow core ceilings.
 - 3. Fixture stems and canopies finished to match fixtures color.
 - 4. Special structural mounting brackets, tenons, slip-fitters, concrete bases, poles, anchor bolts, junction boxes, clips, and stanchions for all exterior lighting fixtures. Provide all weatherproofing and waterproofing for all lighting fixtures to be installed in exterior locations. Provide low temperature ballasts and drivers for all fixtures located in exterior areas.
 - 5. UL fixture tenting and proper and required recessed fixture IC ratings.

PART 3 - EXECUTION

3.1 INSTALLATION OF FIXTURES:

- A. Structural support of all lighting fixtures shall be the responsibility of the Contractor.
- B. Lay-in fixtures for grid type ceilings shall be secured to ceiling grid with approved clips and arrangements for additional ceiling support at each fixture. 1' X 4' and 2' X 2' fixtures shall have 2 each independent additional supports, 2' X 4' fixtures shall have 4 independent additional supports attached to building structural components.
- C. All electrical connections shall be to junction boxes. Fixtures located in drywall ceilings shall be direct conduit connected. Provide access panels in ceilings as required for junction box access.
- D. Provide drywall flange kits or hanger bars for the mounting of all lighting fixtures to be installed in drywall or plaster ceilings. Field coordinate the exact location.
- E. Ceiling mounted fixtures shall be supported independently of ceiling or ceiling tiles and shall be connected, from structural members of building. Minimum of two supports for 4'-0" and 8'-0" fixtures.
- F. The system grounding conductor shall be secured to each fixture body by means of a bonding screw.
- G. All stems for pendant mounted fixtures shall utilize ball aligner assemblies.

- H. Provide canopies for all stem and pendant mounted lighting fixtures and ceiling fans in finished spaces. Provide aligner canopies in finished spaces and swivel hanger box covers in unfinished spaces. All stems, alignors and canopies shall be painted to match the lighting fixture and/or ceiling paddle fan and shall be connected to structural components of the building.
- I. Provide all necessary galvanized channels, clips, bridging as required to span purlins, joists, beams, floors etc., for proper lighting fixture system support. Secure channel and bridging for stationary and permanent supporting means that integrates with the building structure and common materials.
- J. Emergency Life Safety lighting fixtures shall be electrically connected ahead of all local switching and shall have a constant "hot" conductor serving the emergency battery inverter system.

END OF SECTION

SECTION 270500 - SPECIAL SYSTEMS**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. Division 26, Section 260500 “General Provisions” and Electrical Identification sections apply to work specified in this Section.
- C. Division 26, Section 260533 “Raceways” Section applies to work specified in this Section.
- D. Division 26, Section 260519, “Conductors” .
- E. Division 26, Section 260533, “Outlet Boxes” .

1.2 SUBMITTALS

- A. None.

1.3 SUMMARY

- A. Extent, location, and details of special systems work are indicated on drawings.
All Systems will be installed above accessible ceilings in accessible locations.
- B. Applications of special systems specified in this section include the following:
 - 1. Security and CCTV system raceway.
 - 2. Television, telephone and data communication.
- C. Pull Wires, raceways and electrical boxes and fittings which are required in connection with communications systems and are not specified in this section are specified in Division 26, General Provisions sections, “Raceways” and “Electrical Boxes and Fittings” .

1.4 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and the NEC as application to installation of these systems.

1.5 SEQUENCING AND SCHEDULING

- A. Coordinate with other electrical work including wire/cables, electrical boxes and fittings, and raceway, to properly interface installation of communications systems with other work.

PART 2 - PRODUCTS**2.1 MANUFACTURERS**

- A. As indicated.

2.2 SECURITY AND CCTV SYSTEM RACEWAY

- A. Provide a complete security system raceway, including conduit, terminal boxes, outlet boxes, wireways, wallplates, as indicated on drawings.
- B. Coordinate the installation of devices and raceways with the Owner's security system installer.
- C. Provide a 200-pound test pull wire or cord in each and every empty conduit.
- D. Cable, jacks, devices, equipment and punch-down blocks shall be by Others.
- E. See drawings for additional conduit, enclosure and raceway requirements.

2.3 TELEVISION, TELEPHONE, & DATA RACEWAY

- A. Provide a complete data/communication system raceway, including conduit, terminal boxes, outlet boxes, wireways, wall plates, outlet devices as indicated on drawings.
- B. Coordinate the installation of devices and raceways with the data/communication system installer.
- C. Provide a 200-pound test pull wire or cord in each and every empty conduit.
- D. Cable, jacks, devices, equipment and punchdown blocks be by the Contractor.
- E. See drawings for additional conduit, enclosure and raceway requirements.

2.4 COORDINATION

- A. Coordinate with the project Systems Contractors and Installers concerning equipment and instruments to be installed. Provide all boxes and plates necessary to support the installed equipment.

PART 3 - EXECUTION - NOT APPLICABLE

END OF SECTION

SECTION 283000 - DIGITAL, ADDRESSABLE FIRE ALARM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1, and Division 26 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes automatic Networked fire alarm systems, including Fire Alarm Control Panel, remote annunciator, door hold open devices, manual pull stations, heat and smoke detectors, fire alarm horns, visual signal equipment, controls, fire and smoke damper connections, and surge protection devices. Coordinate all wiring and device interfaces with Owner's representative. The work also includes providing and connecting single station type 120v rated smoke detectors for all residential apartment areas. The Fire Alarm System shall meet the latest adopted edition of all local, State of Missouri and City of Saint Louis and all local and State County code amendments, NFPA 72, UL 864-9TH Edition all Federal "ADAG" requirements.
All devices shall be "red" in color with "white" lettering.

1.3 DEFINITIONS

- A. Addressable: Combined hardware and software systems associated with the Fire Alarm Control Panel and field devices which will permit identification or control of an individual device (initiating or signal/control circuit).
- B. Alarm-Initiating Device: A manual station, smoke detector or heat detector.
- C. Alarm Signal: Signifies a state of emergency requiring immediate action. Pertains to signals such as the operation of a manual station and the operation of a sprinkler system flow switch.
- D. Style "4" Initiating Circuits: Circuits arranged and electrically supervised so a single break or single ground fault condition will be indicated by a trouble signal at the fire alarm control panel (FACP) and the circuit will continue to be capable of operation for its intended service in the faulted condition no matter where the break or ground fault condition occurs. (2-wire Class B circuit).
- E. Style "Y" Indicating Circuit: Circuits electrically supervised such that a single break or a single ground fault condition will be indicated by a trouble signal at the FACP and the circuit will continue to be capable of operation for its intended service in the faulted condition no matter where the break or ground fault condition occurs. (2-wire Class B).
- F. Multiplex System: One using signaling method characterized by the simultaneous or sequential transmission, or both, and the reception of multiple signals in a communication channel, including means for positively identifying each signal.

1.4 FACP: FIRE ALARM CONTROL PANEL.

- A. Supervisory Signal: Indicates abnormal status or need for action regarding fire suppression or other protective system.
 - 1. Trouble Signal: Indicates that a fault, such as an open circuit or ground, has occurred in the system.
 - 2. Zone: Initiating device or combination of devices connected to a single alarm-initiating device circuit. (SLC) Zone for addressable systems refers to each identifiable, unique device address.

1.5 SYSTEM DESCRIPTION

- A. General: Complete, zoned, noncoded, addressable, microprocessor based fire detection and alarm system with manual and automatic alarm initiation. Devices located outdoors shall be specifically designed for exterior service. Provide battery back-up based upon total load per NFPA 72. Alarm shall achieve a minimum of 80 db throughout occupiable spaces and meet ADA requirements.
- B. Signal Transmission: Multiplex signal transmission dedicated to fire alarm service only.
- C. Alarm Indication: By transmitting emergency alarms, sounding internal and weatherproof horns, and illumination of ADA strobes.
- D. The fire alarm system shall allow for loading and editing special instructions and operation sequences as required. The system shall be capable of on-site programming to accommodate system expansion and facilitate changes in operation. All software operations shall be stored in a non-volatile programmable memory within the fire alarm control unit. Loss of primary and secondary power shall not erase the instructions stored in memory.
- E. The system shall have the capability of loading software operations from a single node to all other nodes on the network.
- F. Resident software shall allow for full configuration of initiating circuits so that additional hardware shall not be necessary to accommodate future changes. For example, monitoring of normally open contact devices to monitoring of normally closed contact devices, or from sensing of normally open contact devices to sensing a combination circuit and being able to differentiate between the two.
- G. Resident software shall allow for configuration of notification appliance and control circuits so that additional hardware shall not be necessary to accommodate changes. For example, changing a non-coded notification appliance circuit to a coded circuit; or from a slow march time (20 BPM) to fast march time (120 BPM) coding.
- H. The system shall have the capability of recalling alarms and trouble conditions in chronological order for the purpose of recreating an event history.
- I. System connections and conduit and wiring for alarm indicating circuits: Style "Y" Wiring.
- J. System connections and conduit and wiring for alarm-initiation circuits: Style "4" wiring.

1. Transmission to Remote Central Station: Provide wiring to automatically route an alarm, supervisory, and trouble signals to the central station service transmitter that is to be located within main fire alarm control panel utilizing listed and approved dialing equipment. All necessary and required equipment including dialer, wiring and connections shall be by this Contractor.
2. General Alarm: A system general alarm includes:
 - a. Indicating the general alarm condition at the FACP and the integral annunciator.
 - b. Identifying the device that is the source of the alarm at the FACP, and annunciator.
 - c. Initiating audible and visible alarm signals throughout the building.
 - d. Stopping HVAC supply and return fans.
 - e. Initiating transmission of alarm signal to remote central reporting station.
 - f. Close fire/smoke doors.
 - g. Close fire/smoke dampers.
3. Manual station alarm operation initiates a general alarm.
4. Water-flow alarm switch operation: Initiates a general alarm.
5. Smoke or heat detection initiates a general alarm.
6. Elevator Lobby Detection: Activation of any elevator lobby (except the first floor lobby), hoistway or machine room smoke detector shall initiate the elevator Phase I recall system to the affected elevator and initiate an alarm for the zone it is located within. Activation of the lobby smoke detector on the first floor shall send a separate signal to the elevator controller to send the car to the alternate fire department access level.
7. Elevator Machine Room Detection: The elevator machine room smoke detector shall energize a flashing warning light at the designated and alternate fire department access levels.
8. Elevator Shunt Trip: Activation of any elevator hoistway heat detector or the machine room heat detector shall initiate shunt trip of the affected elevator power supply, and by use of an auxiliary contact, initiate an alarm for the zone that it is located within. Provide all necessary interfaces and materials to connect to the shunt trip circuit of the elevator circuit breaker, and power mechanism. Utilize shunt trip power from the breaker controlled. Provide wiring system to the elevator controller for final connection by the elevator contractor. Provide supervision of the shunt trip circuit wiring at the FACP. Upon loss of circuit FACP shall annunciate loss of circuit by audible and visual alarms.
9. Elevator Alarm: Elevator lobby detectors shall be cross zoned, by means of software, to indicate an alarm in the zone covering the corridor where located and indicate that the vertical elevator zone is in alarm as well.

1.6 SUBMITTALS

- A. General: Submit the following according to Conditions of Contract and Division 1 Specification Sections. Contractor shall provide drawn "too scale" complete Fire Alarm shop drawings to the Engineer and authority having jurisdiction for approval and permitting. All drawings shall be signed and sealed by a

separate State of Missouri registered Engineer and this Engineer shall be the Engineer of record for this Fire Alarm system design and installation.

- B. Wiring diagrams from manufacturer differentiating between factory- and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified. Indicate components for both field and factory wiring. Indicate all overhead and underground wiring in conduit indicating all Style "4" and Style "Y" installations.
- C. System operation description covering this specific Project including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
- D. Product certification signed by the manufacturer of the fire alarm system components certifying that their products comply with indicated requirements.
- E. Record of field tests of system.
- F. Load calculations for battery sizing.
- G. Copy of warranty. Warranty shall reflect a minimum of (2) years on all System components. Included shall be a written report of the complete test and inspection of the system per NFPA-72. Report shall be completed within one month prior to the end of the one year labor warranty. Documentation of this commitment shall be provided during the submittal process

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: A certified factory-trained technician is to perform the Work of this Section, making up all terminal cabinets, installing all surge suppressors, and including landing and testing each wire, mounting and connecting all devices, programming the main FACP, trouble shooting and certifying the final system. The Contractor shall be currently licensed by the State of North Carolina for Fire Alarm work, and shall be a certified factory-trained technician. Contractor is responsible for obtaining all required and necessary fire alarm permits from the authority having jurisdiction.
- B. Compliance with Local Requirements: Comply with the standard Building Code, All local ordinances, and regulations, and the requirements of the local jurisdiction.
- C. Comply with State and Federal Americans with Disabilities Act (ADA) requirements.
- D. Comply with NFPA 70, "National Electrical Code."
- E. NFPA Compliance: Provide fire alarm and detection systems conforming to the requirements of the following publications:
 - 1. NFPA 72, "National Fire Alarm Code."
 - 2. American Disability Act (ADA).
- F. NRTL Listing: Provide systems and equipment that are listed and labeled.
 - 1. Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- G. FM Compliance: Provide fire alarm systems and components that are FM-approved.
- H. Coordinate all wiring and device interfaces with the Owner's authorized representative.
- I. Entire fire alarm system and all components shall have (2) year warranty from date of final Certificate of Occupancy.
- J. Fire alarm devices and equipment to be installed outdoors in exterior locations shall be specifically designed and U.L. listed as weather and waterproof. Provide weatherproof Neoprene gaskets between wall mounting surface and fire alarm device for all devices mounted outdoors.

1.8 EXTRA MATERIALS

- A. General: Furnish complete extra materials and labor as required to install, connect and test including all conduit and conductors that will exactly match the products and function as described below. Devices that are not utilized shall be packaged and sealed with protective covering for storage and shall be identified with labels clearly describing contents.

1.	Weatherproof horns/strobes	(6) units
2.	Strobes	(6) unit
3.	Weatherproof horn boxes	(2) unit
4.	Manual pull stations	(6) unit
5.	Smoke detectors and base	(4) unit
6.	Heat detectors and base	(1) unit
7.	Duct smoke detector	(2) unit
8.	Addressable module each type	(2) unit
9.	Relay devices module	(2) unit
10.	Data surge suppressor	(2) unit
11.	Signal circuit surge suppressor	(1) unit
12.	A/C 120v power surge suppressor	(1) unit
13.	Wall mounted combination strobe/Horns	(8) units
14.	Ceiling mounted combination strobe/horns	(8) units
15.	120v rated smoke detectors	(10) units

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: All devices shall be provided for and manufactured by Notifier, Simplex or EST as prior approved by the owner.

2.2 MANUAL PULL STATIONS

- A. Description: Double-action non-break glass, addressable type, fabricated of metal or plastic, and finished in white with molded, raised-letter operating instructions of red color. Address of unit shall be field-settable without special tools.

- B. Station Reset: Key-operated, to the FACP, double-pole, double-throw, switch-rated for the voltage and current at which it operates. Stations have screw terminals for connections.

2.3 SMOKE DETECTORS (PHOTO ELECTRIC)

- A. General: Comply with UL 268, "Smoke Detectors for Fire Protective Signaling Systems." Include the following features:
 - 1. Factory Nameplate: Serial number and type identification.
 - 2. Operating Voltage: 24-V d.c., maximum.
 - 3. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - 4. Plug-In Arrangement: Detector and associated encapsulated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection. The plug connection requires no springs for secure mounting and contact maintenance. Terminals in the fixed base accept building wiring.
 - 5. Visual Indicator: Connected to indicate detector has operated.
 - 6. Addressability: Detectors include a communication transmitter and receiver having a unique identification and capability for status reporting to the FACP. Device shall contain an integral LED which shall flash each time the device is interrogated. Device shall be capable of field setting without special tools.
 - 7. Provide dual contacts where indicated.
- B. Addressable Photoelectric Smoke Detectors: Include the following features and characteristics:
 - 1. Detector Sensitivity: Devices shall have smoke density feature.
 - 2. Sensor: An infrared detector light source with matching silicon cell receiver.
- C. Addressable Duct Smoke Detector: Unit shall be photoelectric-type, with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied. Exterior units shall be specifically designed and U.L. approved for outdoor use or provide weatherproof enclosure. Provide unit with alarm indicator.

2.4 HEAT DETECTORS

- A. Addressable Thermal Detector: Rate-compensated/fixed-temperature type with plug-in base and alarm indication lamp. Detectors have a communication transmitter and receiver with unique identification and capability for status-reporting to the FACP.
- B. Field coordinate the exact location of heat detectors in mechanical spaces with ductwork as to provide unobstructed access to all fire alarm devices.
- C. Provide 120-volt dual convertible contact rated devices where indicated.

2.5 ALARM-INDICATING DEVICES

- A. General: Equip alarm-indicating devices for mounting as indicated. Provide terminal blocks for system connections.
- B. Weather Proof Fire Alarm Horn: Electric Piezo, 24-V d.c., type. When operating, provide a sound pressure level of 90 dB (min), measured 10 feet from the horn. Provide flush-mounted, gasketed weatherproof and waterproof units specifically designed for outdoor use. Combination Audio/ Visual Alarm Devices shall mount on cover of Horn and share common weather proof enclosure. Note: Provide Low Frequency sounder bases as required per NFPA 72-2010.
- C. Addressable Interface Units: Arrange to monitor and/or control system components that are not otherwise equipped for multiplex communication. Units transmit identification and status to the FACP using a communication transmitter and receiver with unique identification and capability for status-reporting to the FACP. Provide separate 24 volt power conductors where required.
- D. Visual Alarm Devices: A.D.A. approved strobe lights with clear polycarbonate lens and xenon flash tube. Mount lenses on an aluminum face plate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.
 - 1. Lamps have a minimum peak intensity of 75 candela unless otherwise noted to be higher. Strobe leads are factory-connected to screw terminals.
 - 2. Combination devices consist of factory-combined, audible Horn device and visual alarm units in a single mounting assembly.

2.6 FIRE ALARM CONTROL PANEL (FACP)

- A. General: Comply with UL 864, "Control Units for Fire-Protective Signaling Systems".
- B. Cabinet: Lockable steel enclosure. Arrange unit so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control unit, provide exactly matching modular unit enclosures. Accommodate all components and allow ample gutter space for interconnection of units, as well as field wiring. Identify each enclosure by an engraved, red-laminated, phenolic resin nameplate. Lettering on the enclosure nameplate shall not be less than 1-inch high.
- C. Systems: Alarm and supervisory systems are separate and independent in the FACP. The alarm-initiating zone boards in the FACP consist of plug-in modules. Construction requiring removal of field wiring for module replacement is not acceptable.
- D. Control Modules: Types and capacities required to perform all functions of the fire alarm systems. Local, visible, and audible signals notify of alarm, supervisory and trouble conditions.
- E. The fire alarm control panel shall be an addressable and networked system as manufactured by Notifier. Provide complete system coordination with manufacturer's representative prior to bidding. The panel and devices and components shall be completely UL listed as a complete system.
- F. Instructions: Provide a typewritten instruction card mounted behind a glass cover in a stainless steel frame. Install the frame in a location observable from the FACP. Include interpretation and appropriate response for fire alarm displays and signals, and briefly describe the functional operation of the system under normal,

alarm, and trouble conditions. A map shall also be provided indicating the rooms with initiation devices and their loop number and address number shown, matching the device address.

2.7 FACP EMERGENCY POWER SUPPLY

- A. General: Components include valve-regulated, recombinant lead acid battery, charger, and an automatic transfer switch. Battery nominal life expectancy is 10 years minimum. Battery and charger shall be provided by this contractor with strict coordination with the FACP manufacturer and Owner.
- B. Alarm Silencing: If the "Alarm Silence" button is pressed, all alarm signals shall cease operation.
- C. System Reset:
 - 1. The "System Reset" button shall be used to return the system to its normal state after an alarm condition has been remedied. Display messages shall provide operator assurance of the sequential steps ("IN PROGRESS", "RESET COMPLETED") as they occur, should all alarm conditions be cleared.
 - 2. Should an alarm condition continue, the system will remain in an alarmed state. System control relays shall not reset. The control unit alarm LED shall remain on. The alarmed points will not require acknowledgement if they were previously acknowledged.
- D. A manual evacuation (drill) switch shall be provided to operate the notification appliances without causing other control circuits to be activated. However, should an actual alarm occur, all alarm functions would occur as described previously.
- E. Activation of an auxiliary bypass switch shall override the selected automatic functions.
- F. The actuation of the "enable one person test" program at the control unit shall activate the "One Person Testing" mode.
- G. The system shall have provisions for disabling and enabling all circuits individually for maintenance or testing purposes.
- H. Power Requirements
 - 1. The control unit shall receive 120 VAC power via a dedicated fused disconnect circuit.
 - 2. The system shall be provided with sufficient battery capacity to operate the entire system upon loss of normal 120 VAC power in a normal supervisory mode for a period of 24 hours with 5 minutes of alarm operation at the end of this period. The system shall automatically transfer to battery standby upon power failure. All battery charging and recharging operations shall be automatic.
 - 3. All circuits requiring system operating power shall be 24 VDC and shall be individually fused at the control unit.
 - 4. The system batteries shall be supervised so that a low battery condition or disconnection of the battery shall be audibly and visibly indicated at the control unit.

2.8 WIRE/CABLE

- A. Line-Voltage: Line voltage conductors shall be solid copper conductors with 600 V-rated insulation. #10 gauge, minimum adjusted for larger gauge long runs.
- B. Initiation Circuits (Loop): Initiation loop conductors shall be West Penn #D991 for 3000'-0" in length and less. West Penn #D995 shall be used for circuits over 3000'-0" in length. Below grade, wet or damp location installed cable, including cable installed on the top of exterior walkways, shall be West Penn AQUASEAL multi-conductor (14 gauge), unless noted otherwise, shall be installed in conduit.
- C. Signal Circuits: Signal circuits shall be #12 AWG THWN 19 strand copper.
- D. Annunciator Circuits: #12 AWG THWN 19 strand copper.
- E. Color Code: Color code shall be strictly adhered to:

		Positive	Negative
Audio/visual*	#12 AWG (THWN)	+orange	-white
E relay circuit	#14 AWG (THWN)	+pink	-black
Door holders	#14 AWG (THWN)	+gray	-black
Gas shutoff	#14 AWG (THWN)	+gray	-black
24 VDC	#14 AWG (THWN)	+red	-black
Automatic (non addressable)	#14 AWG (THWN)	+yellow	-brown
Manual (non addressable)	#14 AWG (THWN)	+blue	-purple

- F. All wire shall be installed in new concealed conduit, minimum ½" conduit

2.9 TAGS

- A. Tags For Identifying Tested Components: Comply with NFPA 72. All new and existing fire alarm junction boxes shall be painted bright red, including inside, outside and cover prior to installing conductors.
- B. All indicating, monitoring, and control devices shall be labeled with its loop and address number permanently attached to the device in plain view. All labels shall be typewritten with an approved label maker utilizing protected coverings; hand labeling is not acceptable.
- C. Each and every wire shall be labeled at each end with SLC #, channel # or signal #. Each separate circuit, initiation, signal and auxiliary shall have a specific number. Label each conductor by this circuit number at the control connections and at each terminal connection in the terminal cabinets.

2.10 SURGE SUPPRESSION

- A. Provide complete signal, horn, data loop and power side surge suppression modules on all wiring entering or leaving the FACP. The Contractor shall repair any damaged components or wiring due to transient voltage surges for a period of one year from substantial completion date at no additional cost.
- B. At the main FACP, install surge suppression devices in a separate lockable metal enclosure which is located directly adjacent to the main FACP. The cabinet shall match the FACP cabinet construction exactly. Utilize

empty FACP terminal cabinet that matches the FACP cabinet exactly. Provide a #6 AWG ground wire on all surge suppressors to the individual building grounding electrode system. All signal, data, d/c power supply surge suppressors shall be Edco #PCH043 with base and hold-down connection clips. 120v A/C devices shall be Edco #HSP121BTRU. Contractor shall follow manufacturer's instructions for installing and connecting surge suppression devices exactly.

- C. Telephone transmission line to UDACT dialer shall have a surge suppression device.

2.11 CONTROL RELAYS

- A. Provide relays for other local control such as roll-up door activation or fire/smoke damper release. Relays shall be 10 amp rated relays. Upon activation of the fire alarm system, the relay shall activate and shutdown the controlled equipment. Locate all relays within 36" of equipment controlled. Provide weatherproof units where indicated or install in weatherproof boxes.

2.12 SIGNAL EXPANDERS

- A. Provide remote audio/visual power supply and battery charger in a self-contained lockable cabinet. Provide (4) Style Y notification circuits, and an integral battery charger. Provide unit with integral 120 volt input A/C power and integral lead acid battery. Provide surge suppression for 120 volt branch circuit and provide a 20 amp 125 vac specification grade key type switch to control the power to the signal expander for maintenance. Identify the 120 volt circuit serving the switch (.i.e panelboard and branch circuit number).

2.13 REMOTE ANNUNCIATOR

- A. Provide a flush mounted LCD remote Annunciator at the building entrance as approved by the local Fire Department. Unit shall be no larger than 12" tall x 12" long, and shall be completely flush mounted in the main lobby of the facility.

2.14 HVAC SHUTDOWN RELAYS

- A. Operation: Provide a data addressable module at each air handling system and exhaust fan for shutdown on alarm from the fire alarm system as per the systems operation description. The unit shall be wired such that it shall be self monitoring for integrity. A failure of the relay or associated wiring shall cause unit shutdown. The coil voltage of the relay shall match the fire alarm control panel voltage and a fire alarm signal shall initiate interruption of the air handling unit starting circuit.

2.15 DOOR HOLD OPEN DEVICES

- A. Equipment: Devices as indicated on the drawings shall be as follows:
 - 1. Door solenoid holder/closer header type 24 volt where required.
 - 2. Two piece magnetic door and wall mount unit 24 volt where required.
 - 3. Provide structural backing in order to mount all magnetic devices.
 - 4. Provide system smoke detector on both sides of door that is held open.

2.16 ELEVATOR RECALL AND DETECTION SYSTEM

- A. Installation: Contractor shall provide all conduit, wiring relays, controls and associated devices and detectors for Phase I and Phase II recall per Missouri Building Code requirements and State Elevator Inspector requirements.

2.17 AUDIO SHUNTING CONNECTION

- A. Provide a wired connection to the facility Room Combining Audio or music System in order to mute and take over all facility Audio productions and dedicate to the Fire Alarm system in the event of alarm.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install system according to NFPA Standards referenced in Parts 1 and 2 of this Section.

3.2 EQUIPMENT INSTALLATION

- A. Manual Pull Stations: Mount semi-flush in recessed back boxes with operating handles as indicated. Devices shall be mounted at 48" above finished floor to the top of device. Provide weatherproof protective guards for devices located in exterior areas or locate addressable modules behind pull stations.
- B. Smoke Detectors: Install ceiling-mounted detectors not less than 4 inches from a side wall to the near edge. Install detectors located on the wall at least 4 inches but not more than 12 inches below the ceiling. For exposed solid joist construction, mount detectors on the bottoms of the joists. On smooth ceilings, install detectors not over 30 feet apart in any direction. Install detectors no closer than 5 feet from air registers.
- C. Audible/Visual Alarm-Indicating Devices: Install at 80 inches to the bottom of device, above the finished floor per ADA requirements. Install speakers or horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille or as indicated. Combine audible and visual alarms at the same location into a single unit.
- D. Visual Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn or as a combination unit. Install at 80 inches to bottom of device per ADA requirements.
- E. Fire Alarm Junction Boxes: Surface mount with tops of cabinets not more than 60 inches above the finished floor.
- F. Coordinate location and final installation of duct smoke detectors with HVAC ductwork installation conditions. Installation of detectors shall be by this Contractor. Contractor shall install all duct smoke detectors in all accessible locations for maintenance.
- G. Install flush mounted devices complete with backbox and speaker grille, and T-bar mounting supports.

3.3 WIRING INSTALLATION

- A. Wiring Method: Install wiring in metal raceway. Conceal raceway except in unfinished spaces and as indicated.

- B. Wiring Within Enclosures: Install conductors parallel with or at right angles to the sides and back of the enclosure. Bundle, lace, and train the conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the wiring diagrams of the system. Make all connections with approved crimp on terminal spade lugs, pressure type terminal blocks, or plug connectors, utilizing approved tool specific for crimp on connections. Wire nut connections are unacceptable. Leave a minimum of 8" wire make-up length at each device and splice. Make up length shall be measured after device is connected or splice is made to front of box. Shields on "SLC" wire shall be made up, twisted together, and taped behind devices at all device locations. SLC drain wire located in FAJB's and FACP shall be surge protected at the main fire alarm cabinet and at all other remote terminal cabinets, and shall be terminated on a terminal strip.
- E. Tee tap connections are strictly prohibited. No wire nut connections are acceptable in any location. No splices shall be installed in any fire alarm junction box except to that individual device.
- D. No fire alarm conductors shall be installed below grade. All wiring shall be overhead installed in concealed conduit minimum 1/2". No underground, on ground or underground splices in pull boxes will be permitted.
- E. All terminal cabinets and terminations shall be above ground.
- F. All conduits used or unused connected to FACP or FACP junction boxes shall be identified and labeled as to destination.
- G. All junction boxes used for fire alarm shall be located a minimum of 12" and maximum of 36" from ceiling grid. Overhead junction boxes may not be installed where accessibility is dependent on removal of a lighting fixture or access cover. No junction box shall be located above drywall ceiling. All fire alarm devices and fire alarm device junction boxes' locations shall be coordinated with all other trades such that all are accessible.
- H. Mounting boxes for horn/strobes control and monitor modules shall be installed in deep junction boxes with extension ring attached.

3.4 GROUNDING

- A. Ground equipment surge suppression. For audio circuits, minimize to the greatest extent possible ground loops, common mode returns, noise pickup, cross talk, and other impairments. Measure, record, and report ground resistance. Provide a #6 AWG grounding conductor in concealed conduit from the individual building grounding electrode system to the FACP and each remote Fire Alarm terminal cabinet from the individual building grounding electrode system where cabinet is located. Terminate ground conductor on multi-conductor lug secured within the cabinet.

3.3 FIELD QUALITY CONTROL

- A. Pretesting: Upon completing installation of the system, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications.

- B. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
- C. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of the witnesses to the preliminary tests.
- D. Final Test Notice: Provide a 10-day minimum notice in writing when the system is ready for final acceptance testing.
- E. Minimum System Tests: Test the system according to the procedures outlined in NFPA 72. Minimum required tests are as follows:
 - 1. Verify the absence of unwanted voltages between circuit conductors and ground.
 - 2. Megger test all conductors other than those intentionally and permanently grounded with electronic components disconnected. Test for resistance to ground. Report readings of less than 1-megohm for evaluation.
 - 3. Test all conductors for short circuits utilizing an insulation-testing device.
 - 4. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on the record drawings.
 - 5. Verify the control unit is in the normal condition as detailed in the manufacturer's operating and maintenance manual.
 - 6. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of the initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
 - 7. Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.
 - 8. Test the system for all specified functions according to the manufacturer's operating and maintenance manual. Systematically initiate specified functional performance items at each station including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications. Observe all voice audio for routing, clarity, and quality, freedom from noise and distortion, and proper volume level.
 - 9. Test both primary power and secondary power. Verify, by test, the secondary power system is capable of operating the system for the period and in the manner specified.
- F. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.
- G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log upon the satisfactory completion of tests.
- H. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.

3.4 CLEANING AND ADJUSTING

- A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer.
- B. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels and adjusting controls and sensitivities to suit actual occupied conditions. Provide up to five prepaid visits to the site for this purpose.

3.5 DEMONSTRATION

- A. Provide the services of a factory-authorized service representative to demonstrate the system and train Owner's maintenance personnel as specified below.
 - 1. Train Owner's maintenance personnel in the location of devices, boxes, procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintaining of the system. Provide a minimum of 6 hours' training. Training shall include a complete project walk down with Owner's authorized representative to identify device locations, junction box locations and surge suppression module locations.
 - 2. Schedule training with the Owner at least seven working days in advance.

END OF SECTION

SECTION 283111 - TWO-WAY EMERGENCY COMMUNICATION SYSTEM**PART 1 - GENERAL****1.1 GENERAL REQUIREMENTS**

- A. Applicable requirements of Section 260000 - Electrical General shall be considered a part of this section and shall have the same force as if printed herein in full.
- B. Product specifications, general design considerations, and installation guidelines are provided in this document. The successful vendor shall meet or exceed all requirements described in this document and/or on the Drawings.

1.2 WORK INCLUDED

- A. The work included under this specification consists of furnishing all labor, equipment, materials, supplies and performing all operations necessary to complete the installation. The Contractor will provide and install all of the required material whether specifically addressed in the Specification or not.
- B. The work shall include, but not be limited to, the following:
 - 1. Furnish and install communication base system, call boxes, graphics, labeling and all associated wiring.

1.3 QUALITY ASSURANCE

- A. Coordination: Coordinate installation with architectural and structural features, equipment installed under other sections of the Specifications.
- B. Components and installation shall be in accordance with the requirements of the International Building Code, NFPA, and ADAAG.

1.4 SHOP DRAWINGS

- A. Shop drawings shall be submitted and shall contain the following:
 - 1. Specification sheet/sheets of technical data on each hardware component
 - 2. Specification sheet(s) on wiring to be utilized
 - 3. One-line schematic riser diagram made specifically for this job
 - 4. Calculation for sizing batteries and power supplies
 - 5. Sequence of operation for the entire system
 - 6. Verification of central supervising station (UL Certified)
 - 7. Equipment and service warranty
 - 8. Scaled floor plans showing device locations and wire routing

PART 2 - PRODUCTS**2.1 APPROVED PRODUCTS**

- A. Approved Two-Way Communication System Manufacturer
 - 1. Rath Area of Refuge

2.2 SYSTEM COMPONENTS

- A. The Base Station shall be installed in a constantly attended locations, main telephone room, or electrical room, and shall have the following components:

1. Stainless steel or powder-coated steel housing, red coil cord emergency Handset, 120vac powered, with battery back-up power for 4 hours operation of any call box and base station.
2. Audible and visual indicator that a call box has been activated.
3. 24vac power supply model capable of supplying power to a minimum of 40 call boxes.
- B. Each Call Box shall be installed in location shown on the drawings, and shall have the following features:
 1. Must comply with Americans with Disabilities Act (ADA)
 2. Hands-free speakerphone with an LED to indicate status of call
 3. Programmable for specific location message of the Call Box. This allows rescue personnel to know the location of the activated CallBox.
 4. Braille faceplate located no higher than 48" for front reach and 54" for side reach above ground level to ensure conformance with the ADA requirements.

2.3 SYSTEM FEATURES

- A. Operational Communication Features
 1. Call Box shall be hands-free operable and be a push-button-once to talk system. Once the button has been pushed, the Call Box will call the Base Station. If no answer at the Base Station, it will automatically call preprogrammed emergency numbers. The Call Box must be capable of being programmed with up to 5 emergency numbers to activate two-way off- site person-to-person voice communications.
 2. Call Box shall have Location Message capability. Call Box must have a minimum 18 second recordable message capability, programmable to play 1 or 2 times. Call Box shall notify called party of the location of the call upon being received at the emergency dispatch center.
 3. Call Box shall be capable of allowing the called party to replay the Location Message if necessary to ensure an understanding of the caller location.
 4. Once call has been made (button pushed), the call can be terminated only by the called party.
 5. Call Box must have a red LED that will light up upon push of the button. The light shall be a solid color when the Call Box is activated and will flash when call has been answered.
 6. Call Box must be capable of being programmed and reprogrammed on-site and remotely.
 7. Operating temperature of call box shall be between -40 deg. F to 150 deg. F.
 8. Call Box shall have EEPROM memory to protect programming.
- B. Graphics and Labeling
 1. Base Station shall have appropriate wording to indicate the location of each call box, located adjacent to the LED associated with each callbox.
 2. Call Box graphics must include "Help Phone," international phone symbol and raised Braille lettering.

PART 3 - EXECUTION

3.1 MONITORING

- A. Contractor shall coordinate with the owner to arrange for an off-site monitoring agency associated with this communication system.

3.2 CABLING

- A. Cabling for two-way communication system shall meet the applicable requirements for pathway survivability. Cabling installation shall consist of one or more of the following:
 1. 2-hour fire-rated circuit integrity (CI) cable

2. 2-hour fire-rated cable system
3. 2-hour fire-rated enclosure or protected area

3.3 TESTING

- A. Prior to completion, contractor shall test the functionality of all call boxes, both for connection to the base station, as well as for successful communication with off-site monitoring agency.

3.4 WARRANTY

- A. System shall be warranted for a period of three years.

END OF SECTION