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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Fire-protection valves and equipment.
3. Sprinkler specialty pipe fittings.
4. Sprinklers.
5. Alarm devices.
6. Pressure gages.

B. All work in this Section shall be performed by a Licensed/Certified Sprinkler Contractor recognized by the state.

C. The contractor shall furnish and pay all costs associated with permits, licensing, drawing reviews, installation inspections, and etc. as required by state and/or local authorities.

1.2 SYSTEM DESCRIPTIONS

A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

B. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from sprinklers that are open. Sprinklers open when heat melts fusible link or destroys frangible device.

1.3 PERFORMANCE REQUIREMENTS

A. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

B. Delegated Design: Design sprinkler systems, including comprehensive design analysis by a Licensed/Certified Sprinkler Contractor recognized by the state.

C. Sprinkler systems design shall be approved by authorities having jurisdiction.

1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water distribution piping, valves, and backflow preventers.

2. Sprinkler Occupancy Hazard Classifications:
a. As specified on drawings.

3. Minimum Density for Automatic-Sprinkler Piping Design:
   a. According to NFPA recommendations.

4. Maximum Protection Area per Sprinkler:
   a. Per UL listing.

5. Total Combined Hose-Stream Demand Requirement:
   a. According to NFPA recommendations.

6. Maximum residual pressure at required flow at each hose-connection outlet is as follows:
   a. NPS 2-1/2 Hose Connections: 175 psig.

D. Seismic Performance: Sprinkler and standpipe piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

1.4 SUBMITTALS

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

B. Shop Drawings: For sprinkler and standpipe systems. Include plans, elevations, sections, details, and attachments to other work.

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

C. Delegated-Design Submittal: For sprinkler and standpipe systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the Licensed/Certified Sprinkler Contractor recognized by the state responsible for their preparation.

D. Qualification Data: For qualified Designer/Installer.

E. Approved Sprinkler Systems Drawings: Working plans, prepared according to NFPA 13 and NFPA 24, that have been approved by authorities having jurisdiction, including hydraulic calculations.

F. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13 and NFPA 24. Include "Contractor's Material and Test Certificates."

G. Field quality-control reports.

H. Operation and maintenance data.
1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler and standpipe systems and providing professional design services needed to assume design responsibility. Base calculations on results of fire-hydrant flow test (to be performed by Installer).

   a. Design Responsibility: Preparation of working plans, calculations, and field test reports by a Licensed/Certified Sprinkler Contractor recognized by the state.

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. NFPA Standards: Sprinkler systems equipment, specialties, accessories, installation, and testing shall comply with the following:

   1. NFPA 13, "Installation of Sprinkler Systems."
   2. NFPA 24, "Installation of Private Fire Service Mains and their Appurtenances."

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

2.2 STEEL PIPE AND FITTINGS

A. Schedule 40, Black-Steel Pipe: ASTM A 135; ASTM A 795. Pipe ends may be factory or field formed to match joining method.

B. Schedule 40, Hot Dipped Galvanized-Steel Pipe: ASTM A 135; ASTM A 795. Pipe ends may be factory or field formed to match joining method.

C. Schedule 10, Black-Steel Pipe: ASTM A 135; ASTM A 795. Pipe ends may be factory or field formed to match joining method.

D. Schedule 10, Hot Dipped Galvanized-Steel Pipe: ASTM A 135; ASTM A 795. Pipe ends may be factory or field formed to match joining method.


G. Uncoated, Steel Couplings: ASTM A 865, threaded.
H. Hot Dipped Galvanized, Steel Couplings: ASTM A 865, threaded.


K. Malleable- or Ductile-Iron Unions: UL 860.


M. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

N. Grooved-Joint, Steel-Pipe Appurtenances:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International, Inc.
      b. Tyco Fire & Building Products LP.
      c. Victaulic Company.
      d. Approved equal.
   2. Pressure Rating: 175 psig minimum.
   3. Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
   5. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 FLEXIBLE CONNECTORS

A. General Requirements for Fire Suppression Systems Flexible Connectors: UL listed or FMG approved for fire suppression service.

B. Flexible connectors shall have materials suitable for system fluid. Include 175-psig minimum working-pressure rating and ends according to the following:
   1. NPS 2 and Smaller: Threaded.
   2. NPS 2-1/2 and Larger: Grooved for use with grooved-end-pipe couplings.

C. Manufacturers:
   1. Flex-Hose Co., Inc.
   2. Metraflex, Inc.
   3. Unaflex, Inc.
   4. Approved equal.
D. Stainless-Steel-Hose/Steel Pipe, Flexible Connectors: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include steel nipples or flanges, welded to hose.

2.4 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick.
   1. Class 125, Cast-Iron Flat-Face Flanges: Full-face gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.5 LISTED FIRE-PROTECTION VALVES

A. General Requirements:
   1. Valves shall be UL listed or FM approved.

B. Check Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Company.
      b. Milwaukee Valve Company.
      c. NIBCO INC.
      d. Approved equal.
   4. Type: Swing check.
   5. Body Material: Cast iron.
   6. End Connections: Flanged or grooved.

C. Bronze OS&Y Gate Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Company.
      b. Milwaukee Valve Company.
      c. NIBCO INC.
      d. Approved equal.
   5. End Connections: Threaded.
D. Iron OS&Y Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Crane Company.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Approved equal.

4. Body Material: Cast or ductile iron.
5. End Connections: Flanged or grooved.

E. Indicating-Type Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Crane Company.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Approved equal.

2. Standard: UL 1091.

4. Valves NPS 2 and Smaller:
   
   a. Valve Type: Ball or butterfly.
   b. Body Material: Bronze.
   c. End Connections: Threaded.

5. Valves NPS 2-1/2 and Larger:
   
   a. Valve Type: Butterfly.
   b. Body Material: Cast or ductile iron.
   c. End Connections: Flanged or grooved.

2.6 TRIM AND DRAIN VALVES

A. General Requirements:

4. Size: Same as connected piping.
5. End Connections: Threaded.
2.7 SPECIALTY VALVES AND EQUIPMENT

A. General Requirements:

3. Size: Same as connected piping.

B. Dry-Pipe Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Tyco Fire & Building Products LP.
   c. Viking Corporation.
   d. Approved equal.
2. Standard: UL 260
3. Body Material: Cast or ductile iron.
5. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
6. End Connections: Flanged or grooved.

C. Air Compressor:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Gast Manufacturing Inc.
   b. General Air Products, Inc.
   c. Viking Corporation.
   d. Approved equal.
2.8 SPRINKLER SPECIALTY PIPE FITTINGS

A. General Requirements for Sprinkler System Fittings: UL listed or FMG approved for fire suppression service.

B. Branch Outlet Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International, Inc.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.
   d. Approved equal.

5. Type: Weld-o-let and thread-o-let.
6. Configurations: Fully welded to main, with welded or threaded outlet connection. Refer to "Piping Schedule" for connection method.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, threaded, or welded.

C. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International, Inc.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.
   d. Approved equal.

4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

D. Branch Line Testers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
b. Fire-End & Croker Corporation.
c. Potter Roemer.
d. Approved equal.

2. Standard: UL 199.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

E. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International, Inc.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.
   d. Approved equal.

4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

F. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International, Inc.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.
   d. Approved equal.

5. Size: Same as connected piping.
7. Inlet and Outlet: Threaded.

G. Flexible, Sprinkler Hose Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Anvil International, Inc.
b. Tyco Fire & Building Products LP.
c. Victaulic Company.
d. Approved equal.

3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
5. Size: Same as connected piping, for sprinkler.

2.9 SPRINKLERS

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

2. Reliable Automatic Sprinkler Co., Inc.
3. Tyco Fire & Building Products LP.
5. Approved equal.

B. General Requirements:


C. Automatic Sprinklers with Heat-Responsive Element:

2. Nonresidential Applications: UL 199.
3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

D. Sprinkler Finishes:

1. As noted on drawings.

E. Special Coatings:

1. As noted on drawings.

F. Sprinkler Escutcheons:

1. Materials, types, and finishes for the specified sprinkler mounting applications. Escutcheons for sprinklers are specified with sprinklers.

G. Sprinkler Guards:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Tyco Fire & Building Products LP.
   c. Viking Corporation.
   d. Approved equal.

2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.10 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Electric Bell Alarm:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Reliable Automatic Sprinkler Co., Inc.
      b. Tyco Fire & Building Products LP.
      c. Viking Corporation.
      d. Approved equal.
   4. Electrically (120-Vac) operated.

C. Water-Flow Indicators:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Reliable Automatic Sprinkler Co., Inc.
      b. Tyco Fire & Building Products LP.
      c. Viking Corporation.
      d. Approved equal.
   4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
   5. Type: Paddle operated.
   7. Design Installation: Horizontal or vertical.

D. Valve Supervisory Switches:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Tyco Fire & Building Products LP.
   c. Viking Corporation.
   d. Approved equal.

3. Type: Electrically supervised.
5. Design: Signals that controlled valve is in other than fully open position.

2.11 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ashcroft, Inc.
   2. Trerice, H.O. Co.
   3. Weiss Instruments, Inc.
   4. Approved equal.

B. Standard: UL 393.

C. Dial Size: 4-1/2-inch diameter.

D. Pressure Gage Range: 0 to 250 psig minimum.

E. Water System Piping Gage: Include "WATER" label on dial face.

F. Air System Piping Gage: Include retard feature and "AIR" label on dial face.

PART 3 - EXECUTION

3.1 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water distribution piping for service entrance to building.

B. Install shutoff valve, pressure gage, drain, and other accessories indicated at connection to water distribution piping.

3.2 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Engineer before deviating from approved working plans.

B. Piping Standard: Comply with requirements in NFPA 13 and NFPA 24 for installation of sprinkler and standpipe piping.

C. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.

D. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install alarm devices in piping systems.

J. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements in NFPA 13 for hanger materials.

K. Install pressure gages on riser or feed main, at each sprinkler test connection and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal-seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

L. Fill sprinkler system piping with water.

M. Drain dry-pipe sprinkler piping.

N. Pressurize and check dry-pipe sprinkler system piping, air-pressure maintenance devices and air compressors.

O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section "Common Work Results for Mechanical."

P. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section "Common Work Results for Mechanical."
3.3 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

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

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. 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.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

I. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.4 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13, NFPA 24 and authorities having jurisdiction.

B. Specialty Valves and Equipment:

1. General Requirements: Install in horizontal or vertical position for proper direction of flow, in main supply to system.
2. Dry-Pipe Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
3. Install air compressor and compressed-air supply piping.
3.5 SPRINKLER INSTALLATION
   A. Install sprinklers as specified on drawings.
   B. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.

3.6 IDENTIFICATION
   A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and NFPA 24.
   B. Identify system components.

3.7 FIELD QUALITY CONTROL
   A. Perform tests and inspections.
   B. Tests and Inspections:
      1. Leak Test: After installation, charge systems 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. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
      4. Energize circuits to electrical equipment and devices.
      5. Start and run air compressors.
      6. Coordinate with fire-alarm tests. Operate as required.
      7. Verify that equipment hose threads are same as local fire-department equipment.
   C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
   D. Prepare test and inspection reports.

3.8 CLEANING
   A. Clean dirt and debris from sprinklers.
   B. Remove and replace sprinklers with paint other than factory finish.

3.9 PIPING SCHEDULE
   A. Wet-pipe sprinkler system, NPS 2 and smaller, shall be the following:
      1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
B. Wet-pipe sprinkler system, NPS 2-1/2 to NPS 6, shall be the following:
   1. Schedule 10, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

C. Dry-pipe sprinkler system, NPS 2 and smaller shall be the following:
   1. Schedule 40, hot dipped galvanized-steel pipe with threaded ends; hot dipped galvanized, gray-iron threaded fittings; and hot dipped galvanized, threaded joints.
   2. All pipe, fittings, and components shall be hot dipped galvanized.

D. Dry-pipe sprinkler system, NPS 2-1/2 to NPS 6, shall be the following:
   1. Schedule 10, hot dipped galvanized-steel pipe with roll-grooved ends; hot dipped galvanized, grooved-end fittings for steel piping; hot dipped galvanized, grooved-end-pipe couplings for steel piping; and hot dipped galvanized, grooved joints.
   2. All pipe, fittings, and components shall be hot dipped galvanized.

3.10 SPRINKLER SCHEDULE

A. Provide sprinkler types and finishes as specified on drawings.

END OF SECTION 211000
SECTION 211100 – CLEAN-AGENT FIRE SUPPRESSION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes and fittings.
2. Actuation hardware.
4. Agent cylinder assemblies.
5. Control panel.
6. System Configuration
7. Conduits and conductors.

B. All work in this Section shall be performed by a Licensed/Certified Fire Protection Chemical Contractor recognized by the state.

C. The contractor shall furnish and pay all costs associated with permits, licensing, drawing reviews, installation inspections, and etc. as required by state and/or local authorities.

1.2 SYSTEM DESCRIPTIONS

A. This specification outlines the requirements for a total flooding clean-agent fire extinguishing system employing waterless fire suppressant. All requirements outlined in this specification must be completed in their entirety. These requirements, which are in accordance with the items listed in Section 1.3, combined with good engineering practices shall be followed in order to produce a safe and effective clean-agent fire extinguishing system.

B. The clean-agent fire extinguishing system shall perform as outlined in the following subsections.

1. Achieve a 6.25% (v/v) extinguishing concentration for Class A (Surface Type Fires) hazards.
2. Achieve a 7.00% (v/v) extinguishing concentration for Class C (Energized Electrical Equipment) hazards.
3. Within 10 seconds, the clean-agent fire extinguishing system shall discharge 95% of the required suppression agent mass.
4. The clean-agent fire extinguishing system shall consist of one or more clean-agent cylinders and related equipment. The cylinders may be either connected to a discharge pipe arrangement separately or connected to a common manifold and discharge pipe arrangement. The agent cylinders shall be filled with clean-agent, and super pressurized with dry nitrogen to a working pressure of 360 PSIG at 70°F.
1.3 GENERAL DESCRIPTION

A. The Fire Alarm-Suppression Control System shall consist of a Control Panel that provides control for all devices that make up the complete system. All control units shall be of a single board design and construction and must be factory equipped with all required controls as described in subsequent sections for each suppression hazard.

B. The system shall perform fire alarm, supervisory, and trouble event initiation, occupant notification, event annunciation, local control functions, fire extinguishing system release, and off premises transmission.

C. The control unit shall be listed to be compatible with Conventional point-type Ionization and Photoelectric Detectors, Normally Open contact type Thermal Detectors and switches, Solenoid Operated Control Heads and Initiators, Factory Mutual Sprinkler Solenoid Valves and Audio-Visual Notification Appliances.

D. The control unit shall have dual release capabilities, where each release circuit shall be capable to fully operate independently with different time delay and abort function.

E. All system components provided with a key-lock feature shall be keyed alike.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design fire suppression system, including comprehensive design analysis by a Licensed/Certified Fire Protection Chemical Contractor recognized by the state, using performance requirements and design criteria indicated.

B. System design shall be approved by authorities having jurisdiction.

C. The design, installation, testing and maintenance of the clean-agent fire extinguishing system shall be in accordance with the following codes, standards and regulatory bodies:

1. ANSI B1.20.1: Standard for pipe threads, General Purpose.
7. UL1266: Standard for Halocarbon Clean-agent Extinguishing System Units.
9. Requirements of the Local Authorities Having Jurisdiction (AHJ).
10. Manufacturer’s application requirements.

D. The complete system shall have the following applicable listings and approvals:

1. Underwriters Laboratories (UL).
2. Factory Mutual Global (FM).

E. The manufacturer shall meet ISO 9001 requirements for the design, production and distribution of the clean-agent fire suppression system.
F. All components of the clean-agent fire suppression system shall be the products of the same manufacturer or listed by that manufacturer as compatible with those devices, components and equipment.

G. Seismic Performance: Clean-Agent fire-suppression system shall withstand the effects of earthquake motions determined according to NFPA 2001 and ASCE/SEI 7.

H. A total flooding clean-agent fire suppression system shall be installed to meet the specified minimum design concentration in all designated spaces to be protected.

1.5 EXCLUSIONS

A. The work listed below shall be provided under other sections of this specification.
1. 120 VAC power supply to the system control panel.
2. Interlock wiring and conduit for shutdown of HVAC and electric power supplies, relays or shunt trip breakers.
3. Connection to local/remote fire alarm system.

1.6 SUBMITTALS

A. The Engineer shall review all submittals for conformance to the drawings and specifications. The contractor shall be required to resubmit any materials, with appropriate modifications, that are found to be in non-conformance with the requirements of the drawings and these specifications after review by the Engineer. Approval of the submittals by the Engineer shall not relieve the Contractor of their responsibility to meet the requirements of the drawings and specifications.

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

C. Engineered Design Drawings: The Contractor shall provide all required documents that shall include the following details:
1. The Licensed/Certified Fire Protection Chemical Contractor shall provide all required installation drawings per NFPA 2001.
2. Plan and riser drawings showing the location of the Control Unit and the locations and necessary installation and mounting details of all field devices such as smoke detectors, manual-release stations and notification appliances. Conduit routings shall be shown, with number of conductors, type of wire, and wire sizes indicated for each conduit segment.
3. Point-to-point wiring diagram showing the termination points for all field-wiring circuits to the internal PCB. All internal wiring and communications cabling shall be shown.
4. A primary-power calculation that details the power requirements for the Control Unit and all field devices such as smoke detectors, notification appliances and releasing solenoids.
5. A secondary power calculation that shows the quiescent and alarm power requirements for the Control Unit and all field devices. Include the periods of time for which the quiescent and alarm power requirements shall be supported in order to determine the necessary standby battery capacity.
D. Shop Drawings: For fire suppression system. Include plans, elevations, sections, details, and attachments to other work.

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

E. Delegated-Design Submittal: For fire suppression system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the Licensed/Certified Fire Protection Chemical Contractor recognized by the state responsible for their preparation.

F. Flow Calculation Reports

1. The Licensed/Certified Fire Protection Chemical Contractor shall provide the following information in the total flooding calculation report.
   a. Customer information and project data.
   b. Hazard information - At a minimum, hazard information shall include the minimum design concentration and adjusted design concentration, minimum and maximum enclosure ambient temperature, minimum clean-agent required, volume of enclosure(s) and any corresponding non-permeable volume, and identify the quantity of discharge nozzles.
   c. Cylinder information - At a minimum, cylinder information shall include total clean-agent required, cylinder capacity, cylinder part number, cylinder quantities (both main and reserve), clean-agent fill amount per cylinder and floor loading per cylinder.
   d. Pipe network information - At a minimum pipe network information shall include pipe type, pipe diameter, pipe length, change in elevation, pipe equivalent length and any added accessory equivalent length. In addition, the following nozzle information shall be provided; number of nozzles and identification of enclosure location, flow rate of associated nozzle, nozzle nominal pipe size, nozzle type and nozzle orifice area.
   e. Pipes and pipe fittings - A detailed list of pipe, by schedule, nominal diameter and length, and fittings, by nominal diameter and quantity.

G. Test Plan

1. The Licensed/Certified Fire Protection Chemical contractor shall submit a test plan that describes how the system equipment and room integrity shall be tested. This shall include a step-by-step description of all tests and shall indicate type and location of test apparatus to be used. At a minimum, the tests to be conducted shall be per NFPA 2001 and any additional supplemental tests required by the AHJ. Tests shall not be scheduled nor conducted until the Engineer-Of-Record approves the test plan.

H. Installation Drawings

1. Three (3) sets of installation drawings for each installed clean-agent fire extinguishing system and one (1) set of the calculation report, owner’s manual and product data sheets shall be submitted to the Engineer.
2. A description of system functionality and a detailed matrix of all the initiating points, control modules, and field circuits that identifies the labeling of all components and
shows the relationships and activation sequences among the various initiating points and the control modules and/or field circuits.

3. The Contractor shall submit a test plan that describes how the system shall be tested. This shall include a step-by-step description of all tests and shall indicate type and location of test apparatus to be used. Tests shall not be scheduled or conducted until the Engineer-Of-Record approves the test plan. At a minimum, the tests to be conducted shall be per the relevant referenced codes and any additional supplemental tests required by the AHJ. Tests shall not be scheduled or conducted until the Engineer-Of-Record approves the test plan.

I. Operation and Maintenance Manuals

1. Two (2) copies of the Manufacturer’s Operations and Maintenance Manual for the clean-agent fire extinguishing system shall be submitted after complete installation.

J. Qualification Data: For qualified Designer/Installer.

K. Approved Fire Suppression System Drawings: Working plans, prepared according to NFPA 2001, that have been approved by authorities having jurisdiction, including agent distribution calculations.

L. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 2001.

M. Field quality-control reports.

N. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. The manufacturer/supplier of the system hardware and components shall have a minimum of fifteen (15) years experience in the design and manufacture of systems of similar type.

2. The manufacturer/supplier of the system shall be certified to ISO 9001 for a minimum period of five (5) years for the design, production and distribution of fire detection, fire alarm and fire suppression systems.

3. The name of the manufacturer/supplier and manufacturer part numbers shall appear on all major components.

4. All devices, components and equipment shall be the products of the same manufacturer/supplier.

5. The system manufacturer/supplier shall have the ability to provide multiple suppression system arrangements to accommodate the performance criteria required by the project.

6. All devices, components and equipment shall be listed by the standardizing agencies (UL and/or FM).

B. Installer Qualifications:
1. Contractor responsibilities shall include designing, fabricating, and installing fire suppression system and providing professional design services needed to assume design responsibility. Base calculations on all construction documents and “As-Built” conditions.

   a. Design Responsibility: Preparation of working plans, calculations, and field test reports by a Licensed/Certified Fire Protection Chemical Contractor recognized by the state.

2. The Contactor shall be trained by the manufacturer to calculate/design, install, test and maintain the clean-agent fire extinguishing system and shall be able to produce a certificate stating such on request.

3. The Contractor shall employ a person who can show proficiency at least equal to a NICET level IV certification in special hazards design.

4. The Contractor shall confirm in writing that he stocks a full complement of spare parts and offers 24-hour emergency service for all equipment being furnished.

1.8 WARRANTY

A. Components provided by the manufacturer shall carry a warranty of five (5) years from the date of substantial completion.

PART 2 - PRODUCTS

2.1 GENERAL

A. The clean-agent fire suppression system shall consist of clean-agent storage cylinder(s), actuation hardware and discharge nozzle(s) attached to a pipe network.

2.2 SYSTEM PERFORMANCE

A. System Discharge

   1. The discharge time required to achieve 95% of the minimum design concentration for flame extinguishment shall not exceed ten (10) seconds.

B. Duration of Protection

   1. 85% of the minimum design concentration shall be maintained for ten (10)-minutes or a sufficiently longer period of time to allow effective emergency action by trained personnel. A level 1 certification in room integrity testing, provided by a recognized manufacturer of room integrity testing equipment, is required.

C. Minimum System Design Limits

   1. Nozzles
a. Nozzles shall be listed and approved for a maximum ceiling height of 16 feet and a minimum ceiling height of 1 foot.

b. Nozzle area coverage for both 360- and 180-degree nozzles shall be a maximum of 40-ft x 44-ft.

c. System Nozzles shall be listed and approved for a minimum of 74 PSIG nozzle pressure.

D. Minimum System Design Limits: Tee Flow Splits

1. Side tee flow split limits shall be listed and approved to accommodate 10% to 30% of the agent through the side tee outlet.

2. Bull tee flow split limits shall be listed and approved to accommodate 30% to 70% of the agent through either bull tee outlets

2.3 PIPE AND FITTINGS

A. Distribution piping and fittings shall be installed in accordance with NFPA 2001, approved piping standards and the engineered fire suppression system manufacturer’s requirements.

2.4 ACTUATION HARDWARE

A. The agent cylinders shall be actuated in accordance with the manufacturer’s applicable design manual.

B. While in the stand-by condition, actuators attached to the cylinder valve shall not be exposed to the cylinder’s internal pressure so as to avoid introducing additional leak paths or accidental discharges.

C. Solenoid actuators shall not require scheduled periodic replacement.

D. The suppression panel shall be UL Listed per UL 864, current edition with the interfacing electric actuators.

2.5 NOZZLES

A. Total flooding clean-agent extinguishing system nozzles shall be made of brass.

B. Each nozzle shall be located in the space per the manufacturer’s guidelines. Nozzles shall have either a 180- or a 360-degree discharge pattern.

C. Each nozzle discharge pattern shall be available in sizes ranging from 1/2-in NPT to 2-in NPT.

D. Within each nozzle size and style, the manufacturer shall offer multiple different orifice areas (minimum of 15).

E. Nozzles shall be UL-Listed and FM-Approved for use with the manufacturer’s clean-agent extinguishing system.
2.6 AGENT CYLINDER ASSEMBLIES

A. Clean-agent shall be stored in cylinders manufactured and marked in accordance with US Department of Transportation (DOT) Specification 4BW-500. The clean-agent cylinders shall be conditioned to 360 PSIG @ 70°F. The system manufacturer shall be able to provide US DOT documentation that the registration number marked on the clean-agent cylinder corresponds to a manufacturing location at a US address.

1. Clean-agent cylinders shall be equipped with a pressure gauge to display internal pressures. The gauge shall be an integral part of the equipment and shall be color-coded for fast referencing of pressure readings.
2. A low-pressure switch shall be provided as standard equipment on the clean-agent cylinders. A decrease in pressure will cause the normally open contacts to close, indicating a trouble condition at the control panel. The low-pressure switch shall be field removable/replaceable while the cylinder is still fully charged.
3. Clean-agent cylinders with capacities in excess of 70-lb clean-agent shall be equipped with an integral liquid level indicator (LLI). The LLI will allow the clean-agent cylinder to remain connected and secured in place while measuring the agent mass.

2.7 CONTROL PANEL:

A. The hazard Control Panel shall consist of a Printed Circuit Board with the main microprocessor and an integral operator interface Module, a primary Power Supply Unit, a 24 VDC Battery backup complete with Battery Charger capable of charging 68 AH batteries, in an 18 gauge painted NEMA 1 steel enclosure with door. The enclosure size shall be capable of housing the Printed Circuit Board, the Power Supply Unit and a Battery of capacity 12 AH at 24 VDC. Battery cabinets shall be available to accommodate batteries of capacity 17 to 68 AH at 24 VDC.

B. The power-supply / charger assembly shall be configurable to accept 120 VAC input voltage, and shall provide 5.4 A at 24 VDC of filtered and regulated power to operate the system and charge the system’s standby battery. The charger assembly shall be capable of charging batteries of capacities up to 68 AH.

C. The Control Panel shall provide two (2) resettable Auxiliary Outputs rated at 2 Amp total at 24 VDC for external use.

D. The battery backup system shall consist of 24 VDC, maintenance free, sealed lead acid batteries of capacity such as to provide for 24 to 90 hours of Standby operation followed by 5 to 10 minutes of Alarm operation in case of failure of AC Mains. The battery charger shall be capable of charging a fully discharged battery within 48 hours.

E. The Control Panel shall supervise and control the overall system operation, including the execution of the site-specific configuration. Its printed circuit board shall contain the hazard-specific input and output circuits.

F. The control unit operator interface module shall provide a digital display, system control switches, and Light emitting diodes (LED’s) to indicate the status of individual input and output circuits and a summary of Alarm, Supervisory and Trouble events.
G. The digital display shall also provide a countdown timer to indicate the time remaining prior to an impending suppression system release. Panels that do not display releasing countdown shall not be acceptable.

H. The operator interface module shall be provided with Light Emitting Diodes (LED) to indicate Power ON, Alarm, Pre-Release, Releasing, Post-Release, Trouble, Supervisory and Signal Silenced.

I. The operator interface module shall have control keys for system operation and shall allow System Diagnostics, Lamp Test, and System Configuration Menu Controls. All access to the menu system shall be password protected.

J. A system buzzer shall announce each Alarm, Supervisory, or Trouble event.

K. The Control Panel shall be provided 3 Class A/B Detection Initiating Device Circuits

1. The Initiating Device Circuits shall all be power limited, and shall be field-configurable in either style of supervision without the use of any converter boards, wiring jumpers, or dip switches. Panels that require the use of Class A/Class B converter boards shall not be permitted.

2. Each circuit shall be capable of supporting Normally Open contact-type alarm devices as well as a minimum of twenty-five (25) Conventional point-type smoke detectors in any combination.

3. The Initiating Device Circuits shall be configurable to activate the Suppression System on the occurrence of any of the alarm and supervisory combination as described in subsequent paragraphs.

4. The contractor shall only utilize smoke or electronic heat detectors that have been UL listed for compatibility with the panel.

5. The Detection Circuit shall be field-configurable in a general alarm detection in a style B or style D of supervision without the use of any converter boards, wiring jumpers, or dip switches.

L. The Control Panel shall be provided 1 Class A/B Manual Release Circuit.

1. The circuit shall be power limited and shall be capable of supporting Manual Pull Stations. The release of agent subsequent to the operation of the Manual Release shall be configurable to be either instantaneous or delayed. If delayed, the time delay shall be 10 seconds, 20 seconds, or 30 seconds. The operation of the Manual Release shall override any existing Abort Station input.

2. The Contractor shall only utilize Pull Stations that have been UL listed for compatibility with the panel.

M. The Control Panel shall be provided 1 Class A/B Abort Circuit.

1. The circuit shall be power limited and shall be capable of being user-configurable to abort a single release output.

2. The abort circuit shall be capable of supporting Abort Stations. When enabled, the abort circuit shall be configurable to operate in up to five (5) modes including UL and disabled.

3. The Contractor shall only utilize Abort Stations that have been UL listed for compatibility with the panel.
N. The Control Panel shall be provided 2 Class A/B Supervisory Circuits.
   1. The supervisory Circuit shall be field-configurable in either style of supervision without
      the use of any converter boards, wiring jumpers, or dip switches. Panels that require the
      use of Class A/Class B converter boards shall not be permitted.
   2. Each circuit shall be power limited.
   3. The supervisory circuit shall be configurable to allow for Supervisory input and
      Detection input to be cross zoned, to release the suppression system.

O. The Control Panel shall be provided 3 Class A/B Notification Circuits.
   1. The Notification Circuits shall be field-configurable in either style of supervision without
      the use of any converter boards, wiring jumpers, or dip switches. Panels that require the
      use of Class A/Class B converter boards shall not be permitted.
   2. Each NAC circuit shall be capable of delivering an output of 1.5 Amps at 24 VDC.
   3. All circuits shall be individually programmable and configurable to activate on one or
      more of the conditions of General Alarm, First Alarm, Pre-Discharge, and Discharge.
   4. In the event of the occurrence of any of the above conditions, the circuits shall be
      configurable to generate the sound pattern of:
      a. Silent.
      b. Pulse at 60 beats per minute Silenceable or Non-Silenceable.
      c. Pulse at 120 beats per minute Silenceable or Non-Silenceable.
      d. Temporal Silenceable or Non-Silenceable.
      e. Steady.
   5. Synchronization of the notification appliance circuit shall be achieved without the use of
      external sync modules.
   6. It shall be possible to configure more than one (1) circuit to activate for the same alarm
      condition.
   7. It shall be possible to override one (1) master code (tone) with another depending on the
      state (i.e., First Alarm, Prerelease, or Release) of the particular suppression zone. No
      supplemental equipment shall be required to perform this functionality.
   8. The contractor shall only utilize Alarm Signals that have been UL listed for compatibility
      with the panel.

P. The Control Panel shall be provided 2 Class B Agent Release Circuits.
   1. The releasing circuits shall be protected against inadvertent activation by a Triple-
      Failure-Redundancy safeguard system. This system shall require the main microprocessor
      to issue two (2) release commands, of opposite polarity and via separate signaling
      channels, combined with a signal from the control unit’s watchdog timer confirming
      proper microprocessor operation, in order to activate a release circuit.
   2. It shall be possible to configure each release circuit for activation based on the following
      configuration criteria of inputs:
      b. Single zone.
      c. Crossed zone.
      d. Each Release Circuit shall be capable of operating the following 24 VDC Release
         Devices in the listed configurations:
e. 1 or 2 Control Heads.
f. 1 FM Sprinkler Solenoid (Group A, B, D, E, G, F, I, J and K).
g. 1 Set of Initiators.

3. The Contractor shall only utilize release devices that have been UL-Listed/FM-Approved for compatibility with the panel.
4. The circuit design shall be such that no additional module(s) or interface circuitry is required to be wired between the Control Panel Release Circuit output terminals and the Release Devices listed above for proper operation of the Suppression System.
5. The circuit shall be configurable so as to provide activation power to Control Heads for ninety (90) seconds.
6. The circuit shall be configurable so that release of agent in the affected area may either be instantaneous or delayed by a maximum of sixty (60) seconds. The site-specific time delay shall be configurable up to the maximum allowed in steps of ten (10) seconds.

Q. The Control Panel shall be provided three (3) Independently Programmable Relays.

1. The Programmable Relays shall be normally de-energized and shall have Form-C contacts rated 3 Amps at 120 VAC / 30 VDC.
2. The contacts shall be programmable to transfer and latch on any one of the following conditions:
   a. General Alarm Condition.
   b. First Alarm Condition.
   c. Pre-Discharge Condition.
   d. Discharge Condition.
   f. Global Abort Input.
   g. Global Supervisory Input.

R. The Control Panel shall be provided one (1) System Trouble Relay.

1. The Trouble Relay shall be normally energized and shall have Form-C contacts rated 3 Amps at 120 VAC / 30 VDC.
2. The relay shall be non-latching and shall transfer on any trouble in the system.

S. All Input and Outputs shall be provided appropriate numbers of terminals of capacity suitable for 18 to 12 AWG wiring.

T. Menu System.

1. The Control Panel menu system shall only be accessible from the user interface keypad. It shall be pass code protected to prevent unauthorized access:

U. Electronic Ionization Detectors

1. The Ionization Detector shall be a dual chamber, low profile, conventional type that senses both visible and invisible products of combustion.
2. The sensing chamber shall permit a full 360 degree smoke entry.
3. The Detector shall mount to a twist-to-lock, vandal-resistant base.
4. The Detector shall be suitable for open-air velocities up to 300 fpm and shall have a nominal sensitivity of 1.3% obscuration per foot.
5. It shall be possible to perform a sensitivity check on the detector without the need for generating smoke.
6. It shall be possible to remotely check the detector sensitivity without removing the device from service and without interrupting its operability.
7. The strength of the Americium 241 radioactive source shall not exceed 0.8 microcurie. Detectors with higher radioactive strengths shall not be acceptable.
8. The Detector shall be provided with two (2) response LED’s. These LED’s shall flash to indicate power and shall light up steady with full brilliance on alarm.
9. It shall be possible to view the operational status of the detector from a 360 degree viewing angle.
10. All field wire connections shall be made to the base through the use of a clamping plate and screw.

V. Electronic Photoelectric Detectors.

1. The Photoelectric Detector shall be a light-scattering, low profile, conventional type that senses a broad range of smoldering and flaming-type fires.
2. The sensing chamber shall permit a full 360 degree smoke entry.
3. The Detector shall mount to a twist-to-lock, vandal-resistant base.
4. The detectors shall be suitable for open air velocities up to 300 fpm and shall have a nominal sensitivity of 1.78 to 3.25% obscuration per foot.
5. It shall be possible to perform a sensitivity check on the detector without the need for generating smoke.
6. It shall be possible to remotely check the detector sensitivity without removing the device from service and without interrupting its operability.
7. The Detector shall be provided a response LED. This LED shall flash to indicate power and shall light up steady with full brilliance on alarm.
8. All field wire connections shall be made to the base through the use of a clamping plate and screw.

W. Electronic Heat Detectors

1. The Electronic Heat Detectors shall be a thermistor-based heat sensor with 135F set-point. The Electronic Heat Detectors shall have a Rate-Of-Rise temperature detection feature rated at 150 F per minute.
2. All field wire connections shall be made to the base through the use of a clamping plate and screw.
3. The Detector shall be provided a response LED. This LED shall flash to indicate power and shall light up steady with full brilliance on alarm.
4. The Detector shall mount to a twist-to-lock, vandal-resistant base.

2.8 SYSTEM CONFIGURATION

A. Activation of the extinguishing system shall be via crossed-zoned smoke detection, or single zone heat detection, or a combination of smoke detection and supervisory inputs. In case of cross zoned smoke detection, one half of the crossed-zoned smoke detection system shall consist of Photoelectric Detectors and the other half of Ionization Detectors.
B. Systems that use multi-criteria detectors that cannot be programmed to respond to the various stages of fire development, or systems that do not use different smoke detection principles to confirm the presence of a flaming fire, shall not be considered as equivalent or as meeting the intent of this specification.

C. Activation of any smoke detector in the suppression zone shall:
   1. Cause a pre-alarm (First Alarm) condition.
   2. Create an audible and visible indication on the control unit display and any associated remote display.
   3. Display the zone of the detector in alarm.
   4. Activate audible pre-alarm notification appliances (e.g., bells) in the affected area.
   5. Perform any necessary control functions such as HVAC equipment shutdown.
   6. Transmit an off-premises report to a Listed central or remote station as specified.

D. Activation of a smoke detector from each of the two crossed zones shall:
   1. Cause a pre-release (Second Alarm) condition.
   2. Create an audible and visible indication on the control unit display and any associated remote display.
   3. Display the zones of the detectors in alarm.
   4. Initiate a programmable time delay, and indicate the time remaining prior to extinguishing-system discharge.
   5. Display the time countdown to system discharge on the user interface display.
   6. Activate audible and visual notification appliances (e.g., horns and strobes) in the affected area.
   7. Perform any necessary control functions such as the closure of dampers.

E. The system shall, upon expiration of the time delay:
   1. Cause a release condition and energize the control head to discharge the extinguishing agent into the protected area.
   2. Create an audible and visible indication on the control unit display and any associated remote display.
   3. Display the attainment of the discharge condition.
   4. Continue to activate the audible and visual notification appliances (i.e., strobes) in the affected area.
   5. Perform any necessary control functions such as the emergency power off of all electrical equipment except for lighting and circuits required for life safety.

F. The extinguishing system shall be capable of manual activation by Dual Action Manual Release Stations. Operation of a Manual Release Station shall cause all alarm and shutdown devices to operate as if the system had operated automatically and shall cause an immediate activation of the fire extinguishing system. Operation of a Manual Release Station shall override the operation of all Abort switches.

G. Abort Stations shall, when operated, interrupt the countdown delay for the activation of the extinguishing system and prevent the operation of any alarms and control functions associated with the discharge of the extinguishing agent. The abort switches shall be momentary, deadman type devices that require a constant force to remain engaged and active. Manual Release
Stations shall override the operation of any Abort Station. Abort Stations shall be configured for operation according to the requirements of the Authority Having Jurisdiction.

2.9 CONDUITS AND CONDUCTORS

A. All conductors shall be enclosed in EMT conduit.

B. All wiring shall be of the proper size to conduct the circuit current, but shall not be smaller than #18 AWG. Wiring for the signaling line circuit shall be in accordance with the manufacturer’s Installation, Operation, and Maintenance Manual. Wire that has scrapes, nicks, gouges, or crushed insulation shall not be used. The manufacturer’s minimum wire-bending radii shall be observed in all enclosures, raceways, and conduits. Aluminum wire shall not be used.

PART 3 - EXECUTION

3.1 CLEAN-AGENT FIRE EXTINGUISHING SYSTEM INSTALLATION

A. The system shall be supplied and installed by a Licensed/Certified Fire Protection Chemical Contractor. The Contractor shall be trained and certified by the manufacturer to design, install and maintain the fire suppression system. The Contractor shall install the system in accordance with the manufacturer’s design, installation, operation and maintenance manual.

3.2 ELECTRICAL SYSTEM INSTALLATION

A. All electrical enclosures, raceways, and conduits shall be provided and installed in accordance with applicable codes and intended use, and shall contain only those electrical circuits associated with the fire-detection and control system. No circuit or circuits that are unrelated to the fire alarm or suppression system shall be routed through the enclosures, raceways, and conduits dedicated to the fire alarm or suppression system.

B. Splicing of circuits shall be kept to a minimum, and is only permitted in an electrical box suitable for the purpose. Appropriate hardware shall be used to make the wire splices. Wires that are spliced together shall have the same color insulation.

C. White colored wire shall be used exclusively for the identification of the neutral conductor of an alternating-current circuit. Green colored wire shall be used exclusively for the identification of the earth-ground conductor of an AC or DC circuit. Appropriate color-coding shall be utilized for all other field wiring.

D. All electrical circuits shall be numerically tagged with suitable markings at each terminal point. All circuits shall correspond with the installation drawings.

E. Locations of all electrical equipment, the Control Panel, and all system components are subject to the approval of the Engineer.

F. All final-acceptance tests shall be performed in the presence of the Engineer and the Authority Having Jurisdiction. The Contractor shall record all equipment, tests and system configurations.
in a format approved by the manufacturer and/or the local Authority Having Jurisdiction. A copy of the commissioning tests and results in accordance with NFPA 3 shall be provided to the Engineer, the Authority Having Jurisdiction, and the Owner.

3.3 ROUTINE MAINTENANCE

A. Routine maintenance on equipment shall be performed as recommended by the manufacturer’s installation, operation and maintenance manual. At a minimum the routine maintenance will include the following by a Licensed/Certified Fire Protection Chemical Contractor for the duration of the Warranty period:

1. Visual Check of Pipe network and distribution nozzles per the operation and maintenance manual.
2. Weight and pressure check of the clean-agent cylinders per the operation and maintenance manual.
3. Inspection of all cylinders and equipment for damage per the operation and maintenance manual.
4. Routine maintenance on the suppression system as a whole shall be performed as recommended by NFPA 2001, current edition.

END OF SECTION 211100
SECTION 220000 - GENERAL PROVISIONS FOR PLUMBING

Reference Section 230000 – General Provisions for Mechanical

END OF SECTION 220000
SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

Reference Section 230500 – Common Work Results for Mechanical

END OF SECTION 220500
SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

Reference Section 230529 – Hangers and Supports for Mechanical Piping and Equipment

END OF SECTION 220529
SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

Reference Section 230548 – Vibration and Seismic Controls for Mechanical Piping and Equipment

END OF SECTION 220548
SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

Reference Section 230553 – Identification for Mechanical Piping and Equipment

END OF SECTION 220553
SECTION 220700 - PLUMBING INSULATION

Reference Section 230700 – Mechanical Insulation

END OF SECTION 220700
SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
   2. Specialty valves.
   3. Flexible connectors.
   4. Escutcheons.
   5. Sleeves.

1.2 SUBMITTALS

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

1.3 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
   B. Comply with NSF 61 for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
   B. Material shall be from single manufacturer (not distributor).

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
   4. 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.
2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.4 TRANSITION FITTINGS

A. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

B. Sleeve-Type Transition Coupling: AWWA C219.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:
   1. Description:
      a. Pressure Rating: 150 psig at 180 deg F.
      b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
   1. Description:
      a. Factory-fabricated, bolted, companion-flange assembly.
      b. Pressure Rating: 150 psig.
      c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:
   1. Description:
      a. Nonconducting materials for field assembly of companion flanges.
      b. Pressure Rating: 150 psig.
      c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:
1. Description:
   a. Electroplated steel nipple complying with ASTM F 1545.
   b. Pressure Rating: 300 psig at 225 deg F.
   c. End Connections: Male threaded or grooved.
   d. Lining: Inert and noncorrosive, propylene.

2.6 FLEXIBLE CONNECTORS

A. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
   2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
   3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

2.7 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.
   B. One Piece, Cast Brass: Polished, chrome-plated finish with setscrews.
   D. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
   E. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.8 SLEEVES

A. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 10, zinc-coated, with plain ends.

2.9 GROUT

   B. Characteristics: Non-shrink; recommended for interior and exterior applications.
   C. Design Mix: 5000-psi, 28-day compressive strength.
   D. Packaging: Premixed and factory packaged.
PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance.

D. Install domestic water piping level without pitch and plumb.

E. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

F. 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.

G. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

H. Install piping adjacent to equipment and specialties to allow service and maintenance.

I. Install piping to permit valve servicing.

J. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

K. Install piping free of sags and bends.

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

3.2 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 pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
3.3 VALVE INSTALLATION

A. 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 4 and smaller.

B. 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. Hose-End Drain Valves: At low points in water mains, risers, and branches.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. NPS 2 and Larger: Sleeve-type coupling.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 to NPS 6: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

A. Support vertical piping and tubing at base and at each floor.

B. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

C. Install hangers for copper 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.

D. Install supports for vertical copper piping every 10 feet.

3.7 CONNECTIONS
A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to equipment and machines to allow service and maintenance.
C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   2. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code.
   3. 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.

3.8 ESCUTCHEON INSTALLATION
A. Install escutcheons for penetrations of walls, ceilings, and floors.
B. Escutcheons for New Piping:
   1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
   2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
   3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
   4. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish.
   5. Bare Piping in Equipment Rooms: One piece, cast brass.
   6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
3.9 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, and walls.

B. Sleeves are not required for core-drilled holes through walls. Sleeve is required regardless for holes through elevated slabs.

C. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

D. Install sleeves in new partitions, slabs, and walls as they are built.

E. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint.

F. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint.

G. Seal space outside of sleeves in concrete slabs and walls with grout.

H. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

I. Install sleeve materials according to the following applications:

1. Sleeves for Piping Passing through Concrete Floor Slabs: Galvanized steel pipe.

2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Galvanized steel pipe.
   a. Extend sleeves 2 inches above finished floor level.
   b. For pipes penetrating floors with membrane waterproofing, extend sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of soil pipe to extend sleeve to 2 inches above finished floor level.

3. Sleeves for Piping Passing through Gypsum-Board Partitions:
   a. Galvanized steel pipe sleeves for pipes smaller than NPS 6.
   b. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.

4. Sleeves for Piping Passing through Exterior Concrete Walls:
   a. Galvanized steel pipe sleeves for pipes smaller than NPS 6.
   b. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.

J. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.
3.10 IDENTIFICATION

A. Identify system components with labels for pipe contents and flow direction.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:
   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 one day 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 tests or inspections, make required corrections and arrange for reinspection.

C. Piping Tests:
   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 a 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.

D. Domestic water piping will be considered defective if it does not pass tests and inspections.

3.12 CLEANING

A. Clean and disinfect potable domestic water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures 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.

3.13 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, NPS 4 and smaller, shall be the following:

   1. Soft copper tube, ASTM B 88, Type L. No joints.

D. Aboveground domestic water piping, NPS 2 and smaller, shall be the following:

   1. Hard copper tube, ASTM B 88, Type L; cast- or wrought- copper solder-joint fittings; and soldered joints.

E. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be the following:

   1. Hard copper tube, ASTM B 88, Type L; cast- or wrought- copper solder-joint fittings; and soldered joints.

3.14 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 valves for piping NPS 2 and smaller. Use ball valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use globe valves for piping NPS 2 and smaller.

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

C. CPVC and PVC valves may **NOT** be used.

END OF SECTION 221116
SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following domestic water piping specialties:
   1. Vacuum breakers.
   2. Backflow preventers.
   3. Strainers.
   4. Hose bibbs.
   5. Wall hydrants.
   6. Drain valves.
   7. Water hammer arresters.
   8. Trap-seal primer valves.

1.2 PERFORMANCE REQUIREMENTS


1.3 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Field quality-control test reports.
C. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. NSF Compliance:
   1. 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. Manufacturers:
a. Ames Co.
b. Conbraco Industries, Inc.
d. Approved equal.

3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      b. MIFAB, Inc.
      d. Woodford Manufacturing Company.
      e. Approved equal.
      
      5. Finish: Chrome or nickel plated.

2.2 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Conbraco Industries, Inc.
      d. Approved equal.
      
      2. Standard: ASSE 1012.
      3. Operation: Continuous-pressure applications.
      5. Body: Bronze.
      7. Finish: Chrome plated.

B. Reduced-Pressure-Principle Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 8 psig maximum, through middle 1/3 of flow range.
5. 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.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Configuration: Designed for horizontal, straight through flow.
8. 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.

C. Double-Check Backflow-Prevention Assemblies:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Conbraco Industries, Inc.
      c. Flomatic Corporation.
      e. Approved equal.
   3. Operation: Continuous-pressure applications, unless otherwise indicated.
   4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
   5. 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.
   6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   7. Configuration: Designed for horizontal, straight through flow.
   8. 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.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or 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: 0.033 inch.
   b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
   c. Strainers NPS 5 and Larger: 0.10 inch.

2.4 HOSE BIBBS

A. Hose Bibbs:
   5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
   10. Finish for Finished Rooms: Chrome plated.
   14. Include operating key with each operating-key hose bibb.
   15. Include integral wall flange with each chrome-plated hose bibb.

2.5 WALL HYDRANTS

A. Non-freeze Wall Hydrants:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. MIFAB, Inc.
      c. Watts Drainage Products Inc.
      d. Woodford Manufacturing Company.
      e. Approved equal.
   4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounting with cover.
12. Operating Keys(s) : One with each wall hydrant.

2.6 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:
2. Pressure Rating: 400-psig minimum CWP.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
8. Inlet: Threaded or solder joint.

2.7 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. MIFAB, Inc.
   c. PPP Inc.
   d. Sioux Chief Manufacturing Company, Inc.
   e. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   f. Watts Drainage Products Inc.
   g. Approved equal.
3. Type: Metal bellows.
4. 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MIFAB, Inc.
   b. PPP Inc.
   c. Sioux Chief Manufacturing Company, Inc.
   e. Watts Industries, Inc.; Water Products Div.
   f. Approved equal.


5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.

6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.

7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.

2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.

3. Do not install bypass piping around backflow preventers.

B. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

C. Install water hammer arresters in water piping according to PDI-WH 201.

D. 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.
3.2 FIELD QUALITY CONTROL

A. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

END OF SECTION 221119
SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes soil and waste, sanitary drainage and vent piping inside the building.

1.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:


1.2 QUALITY ASSURANCE

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

B. Comply with NSF Standards.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

B. Flexible Transition Couplings for Underground Non-pressure Piping: ASTM C 1173 with elastomeric sleeve. Include ends of same sizes as piping to be joined and include corrosion-resistant metal band on each end.

C. Hub-and-Spigot, Cast-Iron Pipe and Fittings: ASTM A 74, Service class.


D. Hubless Cast-Iron Pipe and Fittings: ASTM A 888 or CISPI 301.

1. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.

2. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

   a. Heavy-Duty, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.

D. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
Madison County EOC  January 24, 2014
Richmond, Kentucky

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Special pipe fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.

B. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

C. Aboveground, soil, waste, and vent piping shall be any of the following:
   1. Hubless cast-iron soil pipe and fittings; heavy-duty, shielded, stainless-steel couplings; and hubless-coupling joints.
   2. Copper DWV tube, copper drainage fittings, and soldered joints.

D. Underground, soil, waste, and vent piping shall be any of the following:
   1. Service class, hub-and-spigot, cast-iron soil pipe and fittings; gaskets; and compression joints.

3.2 PIPING INSTALLATION

A. Install cleanouts at finished floor elevation.

B. 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."

C. 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.

D. Install soil and waste drainage and vent piping at a minimum 1/8” per 1 ft. slope.

E. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.3 JOINT CONSTRUCTION

A. Refer to Section "Common Work Results for Mechanical" for basic piping joint construction.

2. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.
3. Hubless Joints: Make with rubber gasket and sleeve.

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.

3.4 HANGER AND SUPPORT INSTALLATION

A. Support vertical piping and tubing at base and at each floor.

B. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

C. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 and smaller: 6 feet with 3/8-inch rod.
2. NPS 2 ½” through NPS 5: 10 feet with 1/2-inch rod.
3. NPS 6: 10 feet with 5/8-inch rod.

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

E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

a. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
b. NPS 3: 60 inches with 1/2-inch rod.
c. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
d. NPS 6: 60 inches with 3/4-inch rod.
e. 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. Support piping and tubing not listed above according to MSS SP-69 and manufacturer’s written instructions.

3.5 CONNECTIONS

A. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

B. 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.
4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

3.6 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. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.

C. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction.

1. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

3.7 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 221316
SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:

1. Cleanouts.
2. Floor drains.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for grease interceptors.

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Cast-Iron Cleanouts:

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

   a. MIFAB, Inc.
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group.
   e. Approved equal.

2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Raised-head, plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Floor Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Sioux Chief Manufacturing Company, Inc.
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group.
   e. Approved equal.

2. Standard: ASME A112.36.2M for threaded, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Threaded, adjustable housing.
5. Body or Ferrule: Cast iron.
7. Closure: Brass plug with straight threads and gasket.
8. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Shape: Round.
11. Top Loading Classification: Medium Duty.
12. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MIFAB, Inc.
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group.
   e. Approved equal.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MIFAB, Inc.
c. Watts Drainage Products Inc.
d. Zurn Plumbing Products Group.
e. Approved equal.

2. Standard: ASME A112.6.3.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

B. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

C. 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. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
3. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

D. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

E. Assemble open drain fittings and install with top of hub 2 inches above floor.

F. Install deep-seal traps on floor drains and other waste outlets.

G. 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.

H. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

I. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
J. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Install piping adjacent to equipment to allow service and maintenance.

3.3 FLASHING INSTALLATION

A. Install flashing for piping passing through roofs with counterflashings or commercially made flashing fittings.

3.4 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.

END OF SECTION 221319
SECTION 221413 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

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

1.2 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.

1.3 SUBMITTALS
   A. Field quality-control inspection and test reports.

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS
   B. Hubless Cast-Iron Pipe and Fittings: ASTM A 888 or CISPI 301.
      1. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
         a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Special pipe fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.

B. Aboveground storm drainage piping NPS 8 and smaller shall be any of the following:
   1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and coupled joints.

C. Underground storm drainage piping NPS 8 and smaller shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.

3.2 PIPING INSTALLATION

A. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers.

B. 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.

C. 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."

D. Make changes in direction for storm 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.

E. Lay buried building drain 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.

F. 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.

G. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
H. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.3 JOINT CONSTRUCTION

3.4 HANGER AND SUPPORT INSTALLATION
A. Install supports according to other Sections.
B. Support vertical piping and tubing at base and at each floor.
C. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
D. 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 to NPS 5: 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: 60 inches with 3/4-inch rod.
   6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
E. Install supports for vertical copper tubing every 10 feet.
F. Install supports for vertical cast-iron soil piping every 15 feet.
G. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS
A. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
B. Connect storm drainage piping to roof drains and storm drainage specialties.

3.6 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.

3.7 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 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following storm drainage piping specialties:

1. Cleanouts.
2. Roof drains.
3. Miscellaneous storm drainage piping specialties.

1.2 SUBMITTALS

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

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Cast-Iron Cleanouts:

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

   a. MIFAB, Inc.
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.
   e. Approved equal.

2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Raised-head, plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Floor Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Watts Drainage Products Inc.
   c. Zurn Plumbing Products Group; Light Commercial Operation.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.
   e. Approved equal.

2. Standard: ASME A112.36.2M for threaded, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Threaded, adjustable housing.
5. Body or Ferrule: Cast iron.
7. Closure: Brass plug with straight threads and gasket.
8. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Shape: Round.
11. Top Loading Classification: Medium Duty.
12. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MIFAB, Inc.
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.
   e. Approved equal.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 ROOF DRAINS

A. Cast-Iron Roof Drains:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MIFAB, Inc.
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Light Commercial Operation.
2. Standard: ASME A112.21.2M.
3. Pattern: As specified on drawings.
5. Dimensions of Body: As specified on drawings.
6. Combination Flashing Ring and Gravel Stop: As specified on drawings.
7. Flow-Control Weirs: As specified on drawings.
8. Outlet: As specified on drawings.
10. Extension Collars: As specified on drawings.
11. Underdeck Clamp: As specified on drawings.

2.3 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Conductor Nozzles:
   1. Description: Metal body with threaded inlet and metal wall flange with mounting holes.
   2. Size: Same as connected conductor.
   3. Finish: As specified on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
   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.

E. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

F. Install conductor nozzles at exposed end of conductors where they spill onto grade.

G. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

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

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.

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.

3.4 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.

END OF SECTION 221423
SECTION 223300 - ELECTRIC DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Commercial, storage electric water heaters.

1.2 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. Operation and maintenance data.

D. Warranty.

1.3 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. 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.

1.4 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 from date of Substantial Completion is three (3) 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. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 COMMERCIAL ELECTRIC WATER HEATERS

A. Commercial, Storage Electric Water Heaters: Comply with UL 1453 requirements for storage-tank-type water heaters.

1. Manufacturers:
   
   a. Lochinvar Corporation.
   b. PVI Industries, LLC.
   c. Smith, A. O. Water Products Company.
   d. Approved equal.


   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:

      1) Staging: Input not exceeding 3 kW per step.

   f. Temperature Control: Adjustable thermostat.
   g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
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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. Capacity and Characteristics as specified on drawings.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

A. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

B. 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.

C. 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.

D. Install thermometer on outlet piping of water heaters.

E. Fill water heaters with water.

3.2 CONNECTIONS

A. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

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.

B. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

END OF SECTION 223300
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Faucets.
   2. Flushometers.
   3. Toilet seats.
   4. Protective shielding guards.
   5. Fixture supports.
   7. Urinals.
   8. Lavatories.
  11. Service sinks.
  12. Laundry trays.

B. Related Sections include the following:
   1. Section "Drinking Fountains and Water Coolers."

1.2 DEFINITIONS


B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. FRP: Fiberglass-reinforced plastic.

D. PMMA: Polymethyl methacrylate (acrylic) plastic.

E. PVC: Polyvinyl chloride plastic.


1.3 SUBMITTALS

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

B. Shop Drawings: Diagram power, signal, and control wiring.
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.


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:

4. Vitreous-China Fixtures: ASME A112.19.2M.

G. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.

H. Comply with the following applicable standards and other requirements specified for bathtub/shower and shower faucets:

1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.

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

2. Brass and Copper Supplies: ASME A112.18.1.

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

3. Off-Floor Fixture Supports: ASME A112.6.1M.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Lavatory Faucets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Delta Faucet Company.
   b. Kohler Co.
   c. Speakman.
   d. Zurn.
   e. Approved equal.
2. Description: As specified on drawings. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
   
   b. Finish: Polished chrome plate.
   c. Maximum Flow Rate: As specified on drawings.

2.2 SHOWER FAUCETS

A. Shower Faucets:
   
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      
      a. Delta Faucet Company.
      b. Kohler Co.
      c. Speakman.
      d. Zurn.
      e. Approved equal.

   2. Description: As specified on drawings. Include hot- and cold-water indicators; check stops; and shower head, arm, and flange. Coordinate faucet inlets with supplies and outlet with diverter valve.
      
      b. Finish: Polished chrome plate.
      c. Maximum Flow Rate: As specified on drawings.

2.3 SINK FAUCETS

A. Sink Faucets:
   
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      
      a. Delta Faucet Company.
      b. Just Mfg.
      c. Kohler Co.
      d. Speakman.
      e. Zurn.
      f. Approved equal.

   2. Description: As specified on drawings. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
      
      b. Finish: Polished chrome plate.
c. Maximum Flow Rate: As specified on drawings.

2.4 FLUSHOMETERS

A. Flushometers:

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

   a. Sloan Valve Company.
   b. Zurn Plumbing Products Group.
   c. Approved equal.

2. Description: As specified on drawings. Flushometer for urinal and/or water-closet-type fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.

   a. Consumption: As specified on drawings.

2.5 TOILET SEATS

A. Toilet Seats:

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

   a. American Standard Companies, Inc.
   b. Church Seats.
   c. Kohler Co.
   d. Approved equal.

2. Description: As specified on drawings. Toilet seat for water-closet-type fixture.

   a. Material: Molded, solid plastic with antimicrobial agent.
   b. Configuration: Open front without cover.
   c. Size: Elongated.
   d. Class: Standard commercial.

2.6 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

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

   a. Insul-Tect Products Co.; a Subsidiary of MVG Molded Products.
   b. TRUEBRO, Inc.
   c. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.
2. Description: As specified on drawings. Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

d. Approved equal.

2.7 FIXTURE SUPPORTS

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

1. MIFAB Manufacturing Inc.
3. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
4. Zurn Plumbing Products Group; Specification Drainage Operation.
5. Approved equal.

B. Water-Closet Supports:

1. Description: As specified on drawings. Combination carrier designed for mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

C. Urinal Supports:

1. Description: As specified on drawings. Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.

D. Lavatory Supports:

1. Description: As specified on drawings. Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.

2.8 WATER CLOSETS

A. Water Closets:

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

   a. American Standard Companies, Inc.
   b. Kohler Co.
   c. Zurn.
d. Approved equal.

2. Description: As specified on drawings.

2.9 URINALS

A. Urinals:

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

   a. American Standard Companies, Inc.
   b. Kohler Co.
   c. Zurn.
   d. Approved equal.

2. Description: As specified on drawings. Wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.

   a. Design Consumption: As specified on drawings.

2.10 LAVATORIES

A. Lavatories:

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

   a. American Standard Companies, Inc.
   b. Kohler Co.
   c. Zurn.
   d. Approved equal.

2. Description: As specified on drawings.

2.11 INDIVIDUAL SHOWERS

A. Individual Showers:

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

   a. Aqua Bath Corporation.
   b. Aqua Glass Corporation.
   c. Kohler Co.
   d. Approved equal.

2. Description: As specified on drawings
2.12 KITCHEN SINKS

A. Kitchen Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Kohler Co.
   b. Elkay Manufacturing Co.
   c. Just Mfg.
   d. Approved equal.

2. Description: As specified on drawings.

2.13 SERVICE SINKS

A. Service Sinks:

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

   a. Crane Plumbing, LLC/Fiat Products.
   b. Kohler Co.
   c. Zurn.
   d. Approved equal.

2. Description: As specified on drawings.

PART 3 - EXECUTION

3.1 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 fixtures level and plumb according to roughing-in drawings.
G. Install water-supply piping with stop on each supply to each fixture to be connected to water
distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

H. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

I. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

J. Install 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.

K. Install toilet seats on water closets.

L. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

M. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

N. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

O. Install shower flow-control fittings with specified maximum flow rates in shower arms.

P. Install traps on fixture outlets.
   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

Q. Install escutcheons at piping wall and ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings.

R. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

3.2 CONNECTIONS

A. 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.

3.3 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.

3.4 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 224700 - DRINKING FOUNTAINS AND WATER COOLERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Electric Water coolers with bottle filler.
2. Fixture supports.

1.2 SUBMITTALS

A. Product Data: Include rated capacities; furnished specialties; and accessories for each type of fixture indicated.

B. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and maintenance data.

1.3 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.


C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.


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 Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products specified.

2.2 ELECTRIC WATER COOLERS

A. Water Coolers: ARI 1010, electric with bubbler, and bottle filler, wall-hanging fixture.
   1. Products:
      a. Elkay Manufacturing Co.
      b. Oasis Corp.
      c. Approved equal.

2. Description: As specified on drawings.

2.3 FIXTURE SUPPORTS

A. Off-Floor, Plumbing Fixture Supports: ASME A112.6.1M, water-cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.
   1. Type II: Bilevel, hanger-type carrier with three vertical uprights.
   2. Supports for Accessible Fixtures: Include rectangular, vertical, steel uprights instead of steel pipe uprights.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Use carrier off-floor supports for wall-hanging fixtures.

B. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.2 INSTALLATION

A. Install off-floor supports affixed to building substrate and attach wall-hanging fixtures, unless otherwise indicated.

B. Install fixtures level and plumb.

C. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball valve. Install valves in locations where they can be easily reached for operation.

D. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
E. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Refer to Section "Basic Mechanical Materials and Methods" for escutcheons.

F. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant.

3.3 CONNECTIONS

A. Connect water supplies from water distribution piping to fixtures.

B. Connect drain piping from fixtures to drainage piping.

3.4 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust water-cooler temperature settings.

END OF SECTION 224700
SECTION 230000 - GENERAL PROVISIONS FOR MECHANICAL

PART 1 - GENERAL

1.1 SCOPE

A. Special Conditions section and General Requirements section are made part of this Division.

B. This Division includes the sections, but not necessarily limited to, listed in the Division Table of Contents.

1.2 GENERAL

A. The work included in this division consists of furnishing all labor, equipment, transportation, excavation, backfill, supplies, material, appurtenances and services necessary for the satisfactory installation of the complete and operating Mechanical System(s) indicated or specified in the Contract Documents.

B. Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete or perfect any part of the Mechanical Systems in a substantial manner, in compliance with the requirements stated, implied or intended in the drawings and/or specifications, shall be included as part of this Contract.

C. It is the intent of this Contract to deliver to the Owner’s a “like new” project once work is complete. Although plans and specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing items which interfere with the new work required for the complete installation without additional cost to the Owner.

1.3 INTENT

A. It is the intention of the Contract Documents to call for finished work, tested and ready for operation.

B. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

1.4 EXAMINATION OF SITE AND CONDITIONS

A. Each Proposer shall inform himself of all conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work. Each Proposer shall also fully acquaint himself with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation.
of materials, facilities and services, availability of utilities, etc. His proposal shall cover all expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after bids are accepted.

1.5 DRAWINGS AND SPECIFICATIONS

A. The drawings are diagrammatic only and indicate the general arrangement of the work to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The drawings are not intended to show every item, which may be necessary to complete the systems. All Proposers shall anticipate that additional items may be required and submit their bid accordingly.

B. The drawings and specifications are intended to supplement each other. No Proposer shall take advantage of conflict between them, or between parties of either. Should this condition exist, the Proposer shall request a clarification not less than twelve days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.

C. The drawings and specifications shall be considered to be cooperative and anything appearing in the specifications, which may not be indicated on the drawings or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.

D. The Contractor shall make all his own measurements in the field and shall be responsible for correct fitting. He shall coordinate this work with all other branches of work in such a manner as to cause a minimum of conflict or delay.

E. The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.

F. Should conflict or overlap (duplication) of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume that he is to be relieved of the work which is specified under his branch until instructions in writing are received from the Engineer.

G. Unless dimensioned, the drawings only indicate approximate locations of equipment, piping, ductwork, etc. Dimensions given in figures on the drawings shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to insure no conflict with other work.

H. Where on the Drawings a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.

I. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.
J. Where on the Contract Documents the word typical is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.

K. Special Note: Always check ceiling heights indicated on Architectural Drawings and Schedules and insure that they may be maintained after all mechanical and electrical equipment is installed. Do not install equipment in the affected area until the conflict is resolved.

1.6 REVIEW OF CONTRACT DOCUMENTS AND FIELD CONDITIONS BY CONTRACTOR

A. By execution of this Contract, the Contractor warrants that he has visited the site of the proposed work, and fully acquainted himself with the conditions there existing relating to construction and labor and that he fully understands the facilities, difficulties, and restrictions attending the execution of the work under Contract. The Contractor further warrants that he has thoroughly examined and is familiar with the drawings, specifications and all other documents comprising the Contract. The Contractor further warrants that by execution of this Contract, his failure, when he was bidding on this Contract, to receive or examine any form, instrument, or document, or to visit the site and acquaint himself with the conditions there existing, in no way relieves the Contractor. The Contractor agrees that the Owner shall be justified in rejecting any claim based on facts regarding conditions for which he should have been on prior notice.

B. Before ordering material or performing any work, the Contractor shall verify all measurements at the work site. Any difference between dimensions on the Drawings and actual measurements shall be brought to the Engineer’s attention for his consideration before the work may proceed. No extra compensation will be allowed because of difference between actual measurements and dimensions indicated on the Drawings. The Contractor shall assume full responsibility for accuracy of measurements obtained at the Work Site.

C. Dimensions, which are lacking, shall be obtained from the Architect. In no case shall Drawings be scaled.

D. All subcontractors shall familiarize themselves with all of the conditions relating to this Contract since the terms set forth in the General Conditions binds all subcontractors to the Contract.

1.7 STRUCTURAL RESPONSIBILITY

A. This contractor, in performing installation of his equipment and related work, shall be responsible for properly bracing, supporting, etc., any construction to guard against cracking settling, collapsing, displacing or weakening. No structural member shall be cut or otherwise weakened in any manner without the expressed consent of the Architect/Engineer.

1.8 WORK LAYOUT

A. This contractor shall layout his work from construction lines and levels established by the General Contractor and shall be responsible for the proper location and placement of his work.
B. Maintain all benchmarks, monuments, and other reference points; replace as directed if disturbed or destroyed.

1.9 UTILITIES
   A. Work confronting existing utilities shall be coordinated with the regulatory agencies and utility companies. Liability for damage to adjacent property and/or utilities shall be the burden of the contractor.

1.10 PROTECTION OF THE BUILDING
   A. This contractor shall not store materials or equipment on any roof of any building in such quantity that these parts of the building will be overloaded in any way.
   B. This contractor shall exercise care and shall confine all work within the contact limit lines.

1.11 PROTECTION OF STORED EQUIPMENT
   A. Provide suitable storage for, and completely protect all materials and equipment prior to installation. Storage shall be dry, clean and safe. Any materials or equipment damaged, deteriorated, rusted or defaced due to improper storage shall be fully repaired, refinished or replaced, as directed by the Engineer, and any materials or equipment lost through theft or mishandling shall be replaced, all without additional cost to the Owner.

1.12 COORDINATION BETWEEN TRADES
   A. Work under this Division shall be coordinated with work of the other Divisions.
   B. Each Proposer shall review all drawings and specifications including Architectural, Mechanical, Electrical, Fire Protection, Landscaping, Structural, Surveys, etc., to insure that the work he intends to provide does not encroach a conflict with or affect the work of others in any way. Where such effect does occur it shall be the Proposer’s responsibility to satisfactorily eliminate any such encroachment conflict or effect prior to the submission of his proposal. Each Proposer shall in particular insure that there is adequate space to install his equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded to the Proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to insure adequate spaces.
   C. It shall be the responsibility of this contractor to leave the necessary room for other trades. No extra compensation will be allowed to cover the cost of relocating piping, equipment, ductwork, etc., or equipment found encroaching on space required by others.
   D. This contractor shall make all mechanical connections, etc., to equipment furnished by others whenever such equipment is shown on any part of the drawings or mentioned in any section of the specifications, unless otherwise specified.
1.13 SUBSTITUTION OF MATERIALS AND EQUIPMENT

A. When this contractor requests approval of substitute materials and/or equipment, except when under formal alternate proposal, it shall be understood and agreed that such substitution, if approved, will be made without cost to the Owner or Engineer, regardless of changes in connections, spacing, electrical services, building space requirements, etc. In all cases where substitutions affect other trades, the contractor offering such substitutions shall reimburse all affected contractors for all necessary changes in their work.

1.14 CODES AND STANDARDS

A. Pertinent Federal, State and Local requirements and regulations are hereby made part of this contract. In case of conflict between Contract Documents and above listed requirements, the latter shall govern. Requirements of authority having local jurisdiction shall supersede all other requirements. Use of the term "code" in sections of the specification refers to applicable requirements and regulations of above agencies.

B. Compliance with the Occupational Safety and Health Act shall be the responsibility of the contractor and under no circumstances shall the Engineer be an authority or be held responsible for any acts concerning this regulation.

C. All equipment and material shall meet the minimum requirements of seismic bracing as governed by the authority having jurisdiction.

1.15 PROJECT CLEAN-UP

A. The Contractor shall export off site, all debris resulting from work under this Division. Burning of debris at the project site is not permitted.

B. Each contractor shall maintain his portion of this project in a neat and orderly fashion, disposing of debris, cartons, crates and boxes as the contents are installed in the project. This clean up shall be accomplished each day in order not to create hardships on the other trades.

1.16 INSTALLATION

A. Installation of all mechanical equipment for the project as specified in these specifications and indicated on the drawings shall be in accordance with the general requirements of this section. Additional installation requirements applicable to individual systems are specified in the specific system section.

B. All equipment shall be installed at locations indicated on the drawings and as specified herein.

C. Assembly and installation of equipment shall be in strict accordance with manufacturer's installation instructions.

D. Equipment shall be securely anchored in place. Care shall be exercised to correctly orient equipment before securing in place.
E. All equipment and material installations shall meet the minimum requirements of seismic bracing as governed by the authority having jurisdiction.

1.17 PERMITS, FEES AND CERTIFICATES

A. Each respective contractor shall obtain and pay all permits and licenses required by Federal, State and Local Ordinances for his type work. All fees in connection with inspections, permits, licenses, approvals, etc. shall be paid by the contractor whose work is affected.

1.18 TESTING AND ADJUSTMENT

A. The complete installation shall be tested as in regular service.

B. Adjust all belts, sheaves, dampers, valves, etc., and leave in full and successful working condition. Lubricate all motors as recommended by manufacturer’s instructions.

C. All failures or defects in workmanship or material, which are revealed by the tests, shall be promptly corrected and the test re-conducted.

D. This Contractor shall be responsible for all materials and labor to provide sheave, belt and/or pulley replacement to meet the required airflows and/or tolerances specified.

1.19 MECHANICAL CONTRACTOR QUALIFICATIONS

A. The successful Mechanical Contracting Firm for this project shall have:

1. Master and Journeyman Plumber’s License.
2. Fire Protection Chemical Contractor License.
3. Heating, Ventilation and Air Conditioning Master Contractor and Journeyman Mechanic License.

1.20 GUARANTEES AND WARRANTIES

A. This Contractor shall guarantee all equipment, apparatus, materials and workmanship entering into this contract to be the best of its respective kind, and shall replace all parts at his own expense, which have been proven defective, per the terms of the Contract. Items of equipment, which may have longer guarantees, shall have warranties and guarantees completed, in order, and in effect at the time of final acceptance of the work by the Engineer/Architect. This contractor shall furnish all such warranties and guarantees at the time of final acceptance of the work.

1.21 SHOP DRAWINGS AND OTHER RELATED SUBMITTALS

A. The type of submittal information required for each item of equipment is scheduled at the end of this section. Unless noted otherwise, eight (8) sets of submittals are required.
B. Unless otherwise specified, materials and equipment must be a standard product of manufacturer's regularly engaged in production of such items.

1. The contractor shall secure right to use any patented article, method or apparatus used in work.
2. When substitute item of equipment has been submitted for approval, the mechanical contractor shall submit layout drawings indicating the changes necessary to adapt the substitute item of equipment to the design, when requested by the Engineer. All cost of the requested drawings shall be the responsibility of the contractor offering the substitutions.
3. Under no circumstances will materials be considered for substitution, which are not a product of a manufacturer regularly engaged in production of such material or which is a product of one who merely assembles products of other manufacturers into fabricated units. Material submitted for substitution shall be subject to express and implied warranties of one manufacturer only.

C. If substitution of material results in incidental extra costs on part of any trade under contract, such costs shall be borne by contractor desiring substitution.

1. Submittal data shall include specification data, such as metal gauges, finishes, optional accessories, etc., even though such equipment and materials may be detailed on the drawings or specified. In addition, the submittal data shall include performance (certification) data, wiring diagrams where applicable, accurate dimensional data and a recommended spare parts list. Outline or dimensional drawings alone are not acceptable.
2. No roughing-in connections, etc., shall be done until approved equipment submittals are in the hands of the contractors. It shall be the contractor's responsibility to obtain approved drawings and to make all connections, etc., in the neatest and most workmanlike manner possible. Each contractor shall coordinate with all other contractors having any connections, roughing-in, etc., to the equipment.
3. In general, normal catalog information (with the particular items underlined or otherwise denoted as being the submitted item) will be acceptable as submittal data. Installation, operating and maintenance instructions must be that information, specifically applicable to the item furnished, ordinarily supplied with the equipment to the owner with any modifications indicated. Wiring diagrams must be correct for the application. Generalized wiring diagrams, showing alternate methods of connection, will not be acceptable unless all unrelated sections are marked out.
4. Submittal data sheets, which indicate several different model numbers, figure numbers, optional accessories, installation arrangements, etc., shall be clearly marked to indicate the specific items of equipment to be furnished. Samples and certificates shall be furnished as requested. Submittal data must be complete for each piece of equipment; piecemeal data will not be processed.
5. It shall be noted that approval of shop drawings by the Engineer applies only to general design, arrangement, type, capacity and quality. Such approval doesn't apply to quantities, dimensions, connection locations and the like. In all cases, the contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, that all equipment fits the available space in a satisfactory manner, and that all connections are suitably located.
6. Before the project is accepted, all submittal data (shop drawings, etc.) must be complete and approved.
7. In addition to shop drawings described above, the following information is required of the contractor to be furnished to the Engineer.
## 1.22 HVAC DOCUMENT REQUIREMENTS

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<th>ITEM OR DESCRIPTION OF EQUIPMENT REQUIRING SHOP DRAWINGS</th>
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<th>Piping &amp; Heating</th>
<th>Plumbing</th>
<th>諮詢</th>
<th>Certifications</th>
<th>Samples</th>
<th>Test &amp; Tagging</th>
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Murphy + Graves Architects
Project No. 1308  GENERAL PROVISIONS FOR MECHANICAL
230000 - 9
### 1.23 MECHANICAL DOCUMENT REQUIREMENTS

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1.24 OPERATION AND MAINTENANCE DATA

A. Submit four sets prior to final inspection bound in 8-1/2 x 11 inch text pages, three D side ring capacity expansion binders with durable plastic covers.

B. Prepare binder covers with printed title “OPERATION AND MAINTENANCE INSTRUCTIONS”. Title of project, and subject matter of binder when multiple binders are required.

C. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.

D. Contents: Prepare a Table of Contents for each volume, with each Product or system description identified, typed on 24-pound white paper.

E. Part I: Directory, listing names, addresses, and telephone numbers of Architect/Engineer, Contractor, Subcontractors, and major equipment suppliers.

F. Part 2: Operation and maintenance instructions, arranged by system and subdivided. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:

   1. Significant design criteria.
   2. List of equipment
   3. Parts list for each component.
   4. Operating instructions.
   5. Maintenance instructions for equipment and systems.
   6. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

G. Part 3: Project documents and certificates, including the following:

   1. Shop drawings and product data.
   2. Power quality test results (including any required grounding tests).
   3. Certificates.
   4. Photocopies of warranties and bonds.

H. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection with Owner’s comments. Revise content of documents as required prior to final submittal.

I. Submit final volumes revised within ten days after final inspection.

1.25 TRAINING/INSTRUCTION
A. General Operating/Maintenance Instruction: Arrange for each installer of work requiring continuing maintenance or operation, to meet with the Owner’s personnel, at project site, to provide basic instructions needed for proper operation and maintenance of entire work. Include instructions by manufacturer’s representatives where installers are not expert in the required procedures. Review maintenance manuals, record documentations, tools, spare parts and materials, lubricants, fuels, identification system, control sequences, hazards, cleaning and similar procedures and facilities. For operational equipment, demonstrate start-up, shutdown, emergency operations, noise and vibration adjustments, safety, economy/efficiency adjustments, energy effectiveness, and similar operations. Review maintenance and operations in relation with applicable Warranties, Agreements to Maintain, Bonds, and similar continuing commitments.

B. Program Structure: Develop an instruction program that includes individual training modules for each system and equipment not part of a system, as required by individual Specification Sections, and as follows:

1. Utilities and Service/Emergency Valves
2. HVAC Controls/Operation.
3. HVAC Equipment & Systems
4. Air Filters and Replacement
5. Fire Protection Dry Chemical and Water Based Suppression Systems
6. Plumbing Fixtures
7. Plumbing System and Valving
8. Domestic Water Heating Systems
9. Collective Protection System
10. Boiler System
11. Shelter-In-Place System

C. Training Modules: Develop a learning objective and teaching outline for each module. Include description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following:

1. Basis of System Design, Operational Requirements, and Criteria: Include system and equipment descriptions, operating standards, regulatory requirements, equipment function, operating characteristics, limiting conditions, and performance curves.
2. Documentation: Review emergency, operations, and maintenance manuals; Project Record Documents; identification systems; warranties and bonds; and maintenance service agreements.
3. Emergencies: Include instructions on stopping; shutdown instructions; operating instructions for conditions outside normal operating limits; instructions on meaning of warnings, trouble indications, and error messages; and required sequences for electric or electronic systems.
4. Operations: Include startup, break-in, control, and safety procedures; stopping and normal shutdown instructions; routine, normal, seasonal, and weekend operating instructions; operating procedures for emergencies and equipment failure; and required sequences for electric or electronic systems.
5. Adjustments: Include alignments and checking, noise, vibration, economy, and efficiency adjustments.
6. Troubleshooting: Include diagnostic instructions and test and inspection procedures.
7. Maintenance: Include inspection procedures, types of cleaning agents, methods of cleaning, procedures for preventive and routine maintenance, and instruction on use of special tools.

8. Repairs: Include diagnosis, repair, and disassembly instructions; instructions for identifying parts; and review of spare parts needed for operation and maintenance.

D. Video/Audio Recording: All Owner Demonstration and Training Sessions shall be video/audio recorded and presented to the Owner in compact disc media. Each session shall be recorded on a dedicated and appropriately labeled compact disc. Three copies of each session disc shall be presented to the Owner at the completion of the project. The Contractor shall pay all associated costs for this method of documentation and media production.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION 230000
SECTION 230500 - COMMON WORK RESULTS FOR MECHANICAL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Piping materials and installation instructions common to most piping systems.
   2. Sleeves.
   3. Identification devices for utilities.
   4. Escutcheons.
   5. Grout.
   6. Demolition.
   7. Equipment installation requirements common to equipment sections.
   8. Duct systems – common requirements.
   9. Concrete bases.
   10. Supports and anchorages.

1.2 DEFINITIONS

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

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

1.3 SUBMITTALS

A. Product Data: For the following:
   1. Identification devices for utilities.

B. Welding certificates.
1.4 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 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.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

A. Refer to individual 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.

2.2 JOINING MATERIALS

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

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

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

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.


G. Solvent Cements for Joining Plastic Piping:
   1. CPVC Piping: ASTM F 493.
   2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
2.3 SLEEVES

A. Galvanized Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 10, plain ends.

2.4 IDENTIFICATION DEVICES FOR UTILITIES

A. Equipment Nameplates: Metal permanently fastened to equipment with data engraved or stamped.
   1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
   2. Location: Accessible and visible.

B. Snap-on Plastic Pipe Markers: Manufacturer's standard preprinted, semi-rigid, snap-on type. Include color-coding according to ASME A13.1, unless otherwise indicated.

C. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers, extending 360 degrees around pipe at each location.

D. 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.

E. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
   1. Arrows: Either integrally with piping system service lettering to accommodate both directions of flow, or as separate unit on each pipe marker to indicate direction of flow.

F. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch sequenced numbers. Include 5/32-inch hole for fastener.
   1. Material: 0.032-inch thick, polished brass.
   2. Size: 1-1/2 inches in diameter, unless otherwise indicated.
   3. Shape: As indicated for each piping system.

G. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks.

H. Engraved Plastic-Laminate 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. Engraving: Engraver's standard letter style, of sizes and with terms to match equipment identification.
   2. Thickness: 1/8 inch, unless otherwise indicated.
   3. Fasteners: Self-tapping, stainless-steel screws or contact-type permanent adhesive.
2.5 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, duct and insulation of insulated piping or duct 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.

2.6 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 DEMOLITION

A. Disconnect, demolish, and remove systems, equipment, and components indicated to be removed.
   1. Piping to Be Removed: Remove entire piping system when section of system is indicated (unless noted otherwise). 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. Equipment to Be Removed: Disconnect, cap services, and remove equipment with all associated appurtenances.
   4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   5. Equipment to Be Removed and Salvaged: Disconnect and cap services, remove equipment, deliver, and store at Owner designated location.
   6. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
   7. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
B. 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 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 by the Engineer.

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.

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

N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and caulk. Select sleeve size to allow for 1/2-inch annular clear space between pipe and sleeve.

O. Fire-Barrier and/or Smoke Rated Penetrations: Maintain indicated fire and/or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials

P. Verify final equipment locations for roughing-in.

Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
R. Painting. All exposed piping installations and supports shall be prepared, primed, and painted. Insulated piping does not require painting. Colors shall conform with ANSI A13.1 “The Scheme for Identification of Piping Systems”.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and 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.


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. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   3. 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.
   4. PVC Nonpressure Piping: Join according to ASTM D 2855.

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. PP Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels.
   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 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.5 IDENTIFICATION FOR UTILITIES

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.
   1. Plastic markers, with application systems. Install on insulation segment if required for hot non-insulated piping.
   2. Locate pipe markers on exposed piping according to the following:
      a. Near each valve and control device.
      b. Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
      c. Near locations where pipes pass through walls or floors or enter inaccessible enclosures.
      d. At manholes and similar access points that permit view of concealed piping.
      e. Near major equipment items and other points of origination and termination.

B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of equipment.
   1. Lettering Size: Minimum 1/4 inch high for name of unit if viewing distance is less than 24 inches, 1/2 inch high for distances up to 72 inches, and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
   2. Text of Signs: Provide name and equipment number of identified unit. Indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Adjusting: Relocate identifying devices that become visually blocked by work of this or other Divisions.
3.6 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible clearances.

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

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

D. Install equipment to allow clearance for piping installed at required slope.

E. All equipment shall be identified with unique equipment number and service (ex. EF-2: RESTROOM 203 EXHAUST FAN).

F. All installed equipment shall meet the seismic bracing requirements of the governing jurisdiction.

3.7 DUCT SYSTEMS - COMMON REQUIREMENTS

A. Install duct according to the following requirements and Sections specifying duct systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct systems. Indicated locations and arrangements were used to size duct and calculate friction loss, expansion, fan sizing, and other design considerations. Install duct as indicated unless deviations to layout are approved by the Engineer.

C. Install duct in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install duct indicated to be exposed and duct in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

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

F. Install duct to permit damper servicing.

G. Install duct free of sags and bends.

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

I. Install duct to allow application of insulation.

J. Install sheetmetal flanges for penetrations of walls, ceilings, and floors.

K. Install sleeves for duct passing through masonry walls.

L. Aboveground, Exterior-Wall Duct Penetrations: Seal penetrations using sleeves, sheetmetal flanges, and caulk. Select sleeve size to allow for 1/2-inch annular clear space between duct and sleeve.
M. **Fire-Barrier and/or Smoke Rated Penetrations:** Maintain indicated fire and/or smoke rating of walls, partitions, ceilings, and floors at duct penetrations. Seal duct penetrations with firestop materials.

N. All exposed and concealed accessible duct installations shall be identified as to service and flow direction with lettering and flow arrows. Duct shall be identified at prominent locations, but in no case at intervals greater than 50 feet.

O. Verify final equipment locations for roughing-in.

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

Q. **Painting.** All exposed duct installations and supports shall be prepared, primed, and painted. Insulated piping does not require painting. Colors shall conform with ANSI A13.1 “The Scheme for Identification of Piping Systems”.

### 3.8 CONCRETE BASES

A. All equipment (regardless whether illustrated or not) shall be supported by a concrete maintenance pad. Pad/base shall be minimum 4 inch above finished floor and minimum 6 inch above finished grade. Roof mounted equipment does not require concrete bases.

B. 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 inch larger in both directions for indoor equipment and not less than 8 inch larger in both directions for outdoor equipment.
2. Height of pad shall be suitable for system operation, condensate drainage, grade conditions, etc.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
4. Chamfer all exposed concrete edges at 1 inch.
5. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Install anchor bolts to elevations required for proper attachment to supported equipment.
8. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
9. Use 4000-psi, 28-day compressive-strength concrete.
10. Unless specified otherwise, reinforcement shall be 6 inch WWF (for indoor installations) and #4 rebar at 12 inch c/c E.W. with 3 inch minimum coverage (for outdoor installations).
3.9ERECTION OF METAL SUPPORTS AND ANCHORAGES
   A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor materials and equipment.
   B. Field Welding: Comply with AWS D1.1.

3.10ERECTION OF WOOD SUPPORTS AND ANCHORAGES
   A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor materials and equipment.
   B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
   C. Attach to substrates as required to support applied loads.

3.11GRouting
   A. Mix and install grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors.
   B. Clean surfaces that will come into contact with grout.
   C. Provide forms as required for placement of grout.
   D. Avoid air entrapment during placement of grout.
   E. Place grout, completely filling equipment bases.
   F. Place grout on concrete bases and provide smooth bearing surface for equipment.
   G. Place grout around anchors.
   H. Cure placed grout.

END OF SECTION 230500
SECTION 230523 - GENERAL-DUTY VALVES FOR MECHANICAL PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Bronze ball valves.
   2. Iron, single-flange butterfly valves.
   3. High-Performance butterfly valves.

1.2 SUBMITTALS

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

1.3 QUALITY ASSURANCE

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

B. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

D. Valve Actuator Types:
   1. Handwheel: For valves other than quarter-turn types and NPS 8 and larger.
   2. Handlever: For quarter-turn valves NPS 6 and smaller.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.


F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.

2.2 BRONZE BALL VALVES

A. Two-Piece, Regular-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Crane Co.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Approved equal.

2. Description:

   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Bronze.
   i. Ball: Chrome-plated brass.
   j. Port: Regular.

2.3 HIGH-PERFORMANCE BUTTERFLY VALVES

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

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

   a. Crane Co.; Crane Valve Group; Flowseal.
   b. Jamesbury; a subsidiary of Metso Automation.
   c. Milwaukee Valve Company.
   d. NIBCO INC.
   e. Approved equal.
2. Description:

   a. Standard: MSS SP-68.
   b. CWP Rating: 285 psig at 100 deg F.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
   e. Seat: Reinforced PTFE or metal.
   f. Stem: Stainless steel; offset from seat plane.
   g. Disc: Carbon steel.
   h. Service: Bidirectional.

B. Class 300, Single-Flange, High-Performance Butterfly Valves:

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

   a. Crane Co.; Crane Valve Group; Flowseal.
   b. Jamesbury; a subsidiary of Metso Automation.
   c. Milwaukee Valve Company.
   d. NIBCO INC.
   e. Approved equal.

2. Description:

   a. Standard: MSS SP-68.
   b. CWP Rating: 720 psig at 100 deg F.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: Carbon steel, cast iron, or ductile iron.
   e. Seat: Reinforced PTFE or metal.
   f. Stem: Stainless steel; offset from seat plane.
   g. Disc: Carbon steel.
   h. Service: Bidirectional.

2.4 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:

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

   a. Crane Co.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Approved equal.

2. Description:

   a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Nickel-plated or -coated ductile iron.

PART 3 - EXECUTION

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

3.2 VALVE INSTALLATION
A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
B. Locate valves for easy access and provide separate support where necessary.
C. Install valves in horizontal piping with stem at or above center of pipe.
D. Install valves in position to allow full stem movement.

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS
A. If valve applications are not indicated, use the following:
1. Shutoff Service: Ball or butterfly valves as indicated.

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

C. Select valves, except wafer types, with the following end connections:
   1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
   2. For Copper Tubing, NPS 2-1/2 to NPS 6: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   3. For Steel Piping, NPS 2 and Smaller: Threaded ends.
   4. For Steel Piping, NPS 2-1/2 to NPS 12: Flanged ends except where threaded valve-end option is indicated in valve schedules below.

3.5 HEATING HOT WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Ball Valves: Two piece, regular port, bronze with bronze trim.

B. Pipe NPS 2-1/2 and Larger:

3.6 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Ball Valves: Two piece, regular port, bronze with bronze trim.

B. Pipe NPS 2-1/2 and Larger:
   1. Iron Valves, NPS 2-1/2: May be provided with threaded ends instead of flanged ends.

END OF SECTION 230523
SECTION 230529 - HANGERS AND SUPPORTS FOR MECHANICAL PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.

B. See Section "Metal Ducts" for duct hangers and supports.

1.2 DEFINITIONS

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

1.3 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes 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.

1.4 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Thermal-hanger shield inserts.

B. Welding certificates.

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 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.
2. ERICO/Michigan Hanger Co.
3. GS Metals Corp.
4. Approved equal.

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.
2. ERICO/Michigan Hanger Co.
3. GS Metals Corp.
4. Approved equal.

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. B-Line Systems, Inc.
   2. ERICO/Michigan Hanger Co.
   4. Approved equal.

C. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass.

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

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

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

2.6 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated 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. Hilti, Inc.
      b. MKT Fastening, LLC.
      c. Powers Fasteners.
      d. Approved equal.

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, steel plates, shapes, and bars; black and galvanized.

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 or copper straps on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

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

F. 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 non-insulated or insulated stationary pipes.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 240 deg F pipes, requiring up to 2 inches of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, requiring clamp flexibility and up to 3 inches of insulation.
   4. U-Bolts (MSS Type 24): For support of heavy pipes.

G. 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 6.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 6, if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
   2. Steel Clevises (MSS Type 14): For 120 to 240 deg F piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
   2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
   3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
   4. C-Clamps (MSS Type 23): For structural shapes.
   5. Side-Beam Brackets (MSS Type 34): For sides of steel beams.
   6. All beam clamps require restraining strap.
J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

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

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

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. 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.

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

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

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, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

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

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

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

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


H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors.

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

J. 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.

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

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

M. 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 to NPS 6: 12 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 as specified.

B. Grouting: Place grout under supports as specified in Section “Common Work Results for Mechanical” 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.

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.

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

END OF SECTION 230529
SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR MECHANICAL PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

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

1.2 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Building Occupancy Category as Defined in ASCE 7: IV.
2. Site Class as Defined in IBC: C.
3. Seismic Design Category as Defined in IBC: C.
4. Design Spectral Response Acceleration at Short Periods (0.2 Second): .193.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
   b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation. The professional engineer must be licensed/registered for the state that the project is located.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
   a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.

3. Field-fabricated supports.

4. Seismic-Restraint Details:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events.
   c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Welding certificates.

D. Field quality-control test reports.

E. Qualification Data: For professional engineer. The professional engineer must be licensed/registered for the state that the project is located.

1.4 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the 2007 Kentucky Building Code and ASCE Standard 7, unless requirements in this Section are more stringent.

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

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

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

1. Amber/Booth Company, Inc.
3. Mason Industries.
4. Approved equal.

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

1. Resilient Material: Oil- and water-resistant neoprene, rubber, or hermetically sealed compressed fiberglass.

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

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Restrained Mounts: All-directional mountings with seismic restraint.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
   1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
   2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
   3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
   1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
   2. Base: Factory drilled for bolting to structure.
   3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel up or down before contacting a resilient collar.

H. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

I. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
   1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
J. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

L. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.
2. Cooper B-Line, Inc.; a division of Cooper Industries.
3. Hilti, Inc.
5. Mason Industries.
6. Unistrut; Tyco International, Ltd.
7. Approved equal.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

D. Restraint Cables: ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

F. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

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

H. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.2 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

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

B. Equipment Restraints:
   1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
C. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
   3. Brace a change of direction longer than 12 feet.

D. Install cables so they do not bend across edges of adjacent equipment or building structure.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

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

G. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

H. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Set anchors to manufacturer's recommended torque, using a torque wrench.
   5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements for piping flexible connections.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Engineer, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Engineer's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least two of each type and size of installed anchors and fasteners selected by Engineer.
5. Test to 90 percent of rated proof load of device.
7. Measure isolator deflection.
8. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.
### 3.6 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

<table>
<thead>
<tr>
<th>EQUIPMENT/ SYSTEM TYPE</th>
<th>ISOLATOR TYPE</th>
<th>BASE TYPE</th>
<th>COMPONENT IMPORTANCE FACTOR (I_p)</th>
<th>COMPONENT AMPLIFICATION FACTOR</th>
<th>COMPONENT RESPONSE MODIFICATION FACTOR</th>
<th>SEISMIC RESTRAINT SYSTEM REQUIRED (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooftop VAV HVAC Units</td>
<td>NR</td>
<td>Structural Frame</td>
<td>1.0</td>
<td>2.5</td>
<td>6.0</td>
<td>Y</td>
</tr>
<tr>
<td>Inline Pumps</td>
<td>Spring Hangers w/Vertical Limit Stop</td>
<td>NA</td>
<td>1.0</td>
<td>1.0</td>
<td>2.5</td>
<td>Y</td>
</tr>
<tr>
<td>Ceiling-Mounted and In-Line Exhaust Fans</td>
<td>Spring Hangers w/Vertical Limit Stop</td>
<td>NA</td>
<td>1.0</td>
<td>2.5</td>
<td>6.0</td>
<td>Y. See Exemptions</td>
</tr>
<tr>
<td>Condensing Boilers</td>
<td>NR</td>
<td>NA</td>
<td>1.0</td>
<td>2.5</td>
<td>6.0</td>
<td>Y</td>
</tr>
<tr>
<td>Variable Refrigerant Volume Indoor Units</td>
<td>Spring</td>
<td>Spring</td>
<td>1.0</td>
<td>2.5</td>
<td>6.0</td>
<td>Y</td>
</tr>
<tr>
<td>Variable Refrigerant Volume Outdoor Unit</td>
<td>NR</td>
<td>Structural Frame</td>
<td>1.0</td>
<td>2.5</td>
<td>6.0</td>
<td>Y</td>
</tr>
<tr>
<td>Hydronic Piping</td>
<td>NR</td>
<td>NA</td>
<td>1.0</td>
<td>2.5</td>
<td>4.5</td>
<td>Y. See Exemptions</td>
</tr>
<tr>
<td>Ductwork</td>
<td>NR</td>
<td>NA</td>
<td>1.0</td>
<td>2.5</td>
<td>6.0</td>
<td>Y. See Exemptions</td>
</tr>
<tr>
<td>Water Heaters</td>
<td>NR</td>
<td>NA</td>
<td>1.0</td>
<td>1.0</td>
<td>2.5</td>
<td>Y</td>
</tr>
<tr>
<td>Hydronic Expansion Tank and Air Separator</td>
<td>NR</td>
<td>NA</td>
<td>1.0</td>
<td>1.0</td>
<td>2.5</td>
<td>Y</td>
</tr>
<tr>
<td>Natural Gas Piping</td>
<td>NR</td>
<td>NA</td>
<td>1.5</td>
<td>2.5</td>
<td>9.0</td>
<td>Y</td>
</tr>
<tr>
<td>Domestic Water Piping</td>
<td>NR</td>
<td>NA</td>
<td>1.0</td>
<td>2.5</td>
<td>6.0</td>
<td>Y. See Exemptions</td>
</tr>
<tr>
<td>Sanitary Sewer Piping</td>
<td>NR</td>
<td>NA</td>
<td>1.0</td>
<td>2.5</td>
<td>6.0</td>
<td>Y. See Exemptions</td>
</tr>
<tr>
<td>CRAC Unit</td>
<td>Isolation Pad</td>
<td>NA</td>
<td>1.0</td>
<td>2.5</td>
<td>6.0</td>
<td>Y</td>
</tr>
</tbody>
</table>
### Mechanical Seismic-Restraint Exemptions:

1. Mechanical components in Seismic Design Category B.
2. Mechanical components in Seismic Design Category C provided that $I_p = 1.0$.
3. Mechanical components in Seismic Design Categories D, E, and F where $I_p = 1.0$ and either:
   - a. Flexible connections between the components and associated ductwork and piping are provided.
   - b. Components are mounted at 4 ft or less above a floor level and weigh 400 lb or less.
4. Mechanical components in Seismic Design Categories D, E, and F where $I_p = 1.0$ and:
   - a. Flexible connections between the components and associated ductwork and piping are provided.
   - b. The components weigh 20 lb or less or, for distribution systems, weighing 5 lb/ft or less.
5. HVAC ductwork in any Seismic Design Category where $I_p = 1.0$ and either:
   - a. The ductwork is suspended from hangers 12” or less in length for the full length of each duct run. The hangers shall avoid significant bending.
   - b. The ductwork has a cross-sectional area of less than 6 ft² for the full length of each duct run.
6. Piping systems (excluding fire protection sprinkler piping and ASME pressure piping) where one of the following conditions is met:
   - a. The piping is supported by rod hangers 12” or less in length from top of pipe to supporting structure. The hangers shall avoid significant bending and provisions shall be made to accommodate piping deflections.
   - b. High-deformability piping is used; provisions are made to avoid impact with larger piping or mechanical components or to protect the piping in the event of such impact; and the following size requirements are satisfied:

<table>
<thead>
<tr>
<th>Variable Air Volume Boxes</th>
<th>Spring Hanger</th>
<th>NA</th>
<th>1.0</th>
<th>2.5</th>
<th>6.0</th>
<th>Y. See Exemptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Unit Heaters</td>
<td>NR</td>
<td>NA</td>
<td>1.0</td>
<td>2.5</td>
<td>6.0</td>
<td>Y. See Exemptions</td>
</tr>
<tr>
<td>Make-up Air Unit</td>
<td>NR</td>
<td>Structural Frame</td>
<td>1.0</td>
<td>2.5</td>
<td>6.0</td>
<td>Y. See Exemptions</td>
</tr>
</tbody>
</table>

**LEGEND:**
- NA = Not Applicable
- NR = Not Required
- Y = Yes
- N = No
1) For Seismic Design Categories D, E, and F where $I_p$ is greater than 1.0, the nominal pipe size shall be 1” or less.

2) For Seismic Design Category C where $I_p$ is greater than 1.0, the nominal pipe size shall be 2” or less.

3) For Seismic Design Categories D, E, and F where $I_p = 1.0$, the nominal pipe size shall be 3” or less.

7. ASME Pressure Piping in (accordance with ASME B31) and Fire Protection Sprinkler System Piping (in accordance with NFPA 13) are NOT exempt.

END OF SECTION 230548
SECTION 230553 - IDENTIFICATION FOR MECHANICAL PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.

1.2 SUBMITTAL

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

B. Sample: For each type of product indicated.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
   4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
   5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 2-1/2 inches.
   6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds the size of principal lettering.
   7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's unique equipment number and service (ex. EF-1: Elevator Machine Room 140).

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and service. Equipment schedule shall be included in operation and maintenance data.
2.2 WARNING SIGNS AND LABELS

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


C. Background Color: Red.

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

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 2-1/2 inches.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

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

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. NPS 1-1/2 and Smaller. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

C. NPS 2 and Larger. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

PART 3 - EXECUTION

3.1 PREPARATION

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

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

B. Locate equipment labels where accessible and visible.

3.3  PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces; and as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings and inaccessible enclosures.
4. At access doors 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.

B. Pipe Label Color Schedule:

1. Refrigerant Piping:
   a. Background Color: Green.

2. Domestic Cold Water Piping:
   a. Background Color: Blue.

3. Domestic Hot Water Piping:
   a. Background Color: Red.

4. Domestic Hot Water Recirculation Piping
   a. Background Color: Orange.

5. Natural Gas Piping (Located Indoors):
   a. Background Color: Yellow.
   b. Letter Color: Black.

6. Hydronic Heating Water Piping:
   a. Background Color: Green.

7. Condensate Piping:
   a. Background Color: Green.

8. Storm Drain Piping
   a. Background Color: Black.

END OF SECTION 230553
SECTION 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes TAB to produce design objectives for the following:

1. Air Systems:
   a. Constant-volume air systems.
   b. Variable-air-volume systems.

2. Hydronic Piping Systems:
   a. Constant-flow systems.

3. HVAC equipment quantitative-performance settings.
4. Verifying that automatic control devices are functioning properly.
5. Reporting results of activities and procedures specified in this Section.
6. Duct leakage testing.

1.2 SUBMITTALS

A. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

B. Certified TAB Reports: Submit five (1-Architect, 1-Engineer, 3-O&M Manuals) copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

C. Warranties specified in this Section.

1.3 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by AABC.

B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

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

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

1.5 COORDINATION
   A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
   B. Perform TAB after pressure tests on water distribution systems have been satisfactorily completed.
   C. Perform TAB after leakage and pressure tests on air distribution systems have been satisfactorily completed.

1.6 WARRANTY
   A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
      1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
      2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
      1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
   B. Examine approved submittal data of HVAC systems and equipment.
C. Examine Project Record Documents.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, and adjusting as specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

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

L. Examine strainers for clean screens and proper perforations.

M. Examine two-way and three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

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

O. Examine equipment for installation and for properly operating safety interlocks and controls.

P. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices are operated by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, three-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at indicated values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:
   1. Permanent electrical power wiring is complete.
   2. Hydronic systems are filled, clean, and free of air.
   3. Automatic temperature-control systems are operational.
   4. Equipment and duct access doors are securely closed.
   5. Balance 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.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. For variable-air-volume systems, develop a plan to simulate diversity.

C. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

D. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling unit components.

K. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

   a. Measure outlet static pressure as far downstream from the fan as practicable 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 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.

2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

   a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, and any other operating modes 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 static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

   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. 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 terminal 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. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using 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.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set outside-air dampers at minimum, and return-dampers at a position that simulates full-cooling load.

2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.

3. Measure total system airflow. Adjust to within indicated airflow.

4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.

   a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.

8. Record the final fan performance data.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

   1. Open all manual valves for maximum flow.
   2. Check flow-control valves for specified sequence of operation and set at indicated flow.
   3. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
   4. Set system controls so automatic valves are wide open to heat exchangers.
   5. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
   6. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR HYDRONIC SYSTEMS

A. Set calibrated balancing valves, if installed, at calculated presettings.
B. Measure flow at all stations and adjust, where necessary, to obtain first balance.
   1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

C. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

D. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
   1. Determine the balancing station with the highest percentage over indicated flow.
   2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
   3. Record settings and mark balancing devices.

E. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

F. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.9 PROCEDURES FOR MOTORS

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

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

3.10 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.
3.11 TEMPERATURE-CONTROL VERIFICATION
   A. Verify that controllers are calibrated and commissioned.
   B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
   C. Check free travel and proper operation of control devices such as damper and valve operators.
   D. Check the interaction of interlock and lockout systems.
   E. Note operation of electric actuators using spring return for proper fail-safe operations.

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

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

3.14 ADDITIONAL TESTS

A. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 230593
SECTION 230700 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Insulation Materials:
      a. Flexible elastomeric.
      b. Mineral fiber.
   2. Adhesives.
   3. Sealants.
   4. Factory-applied jackets.
   5. Tapes.

1.2 SUBMITTALS

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

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 pipe expansion joints for each type of insulation.
   3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   4. Detail removable insulation at piping specialties, equipment connections, and access panels.
   5. Detail field application for each equipment type.

C. Field quality-control reports.

1.3 QUALITY ASSURANCE

A. 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.
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. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

D. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

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

      a. Armacell LLC.
      b. RBX Corporation.
      c. Approved equal.

E. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

      b. Knauf Insulation.
      c. Owens Corning.
      d. Approved equal.

F. Mineral-Fiber, Preformed Pipe Insulation:

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

      b. Knauf Insulation.
      c. Owens Corning.
      d. Approved equal.

   2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

G. 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 "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. CertainTeed Corp.; Commercial Board.
   b. Johns Manville; 800 Series Spin-Glas.
   c. Knauf Insulation; Insulation Board.
   d. Owens Corning; Fiberglas 700 Series.
   e. Approved equal.

2.2 ADHESIVES

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

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Products.
      b. Foster Products Corporation.
      c. Mon-Eco Industries, Inc.
      d. Approved equal.

C. ASJ and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Products.
      b. Foster Products Corporation.
      c. Mon-Eco Industries, Inc.
      d. Approved equal.

2.3 SEALANTS

A. FSK Flashing Sealants:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Products.
      b. Foster Products Corporation.
      c. Mon-Eco Industries, Inc.
      d. Approved equal.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.

B. ASJ and PVC Flashing Sealants:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Products.
      b. Approved equal.
   2. Materials shall be compatible with insulation materials, jackets, and substrates.
   3. Fire- and water-resistant, flexible, elastomeric sealant.
   4. Service Temperature Range: Minus 40 to plus 250 deg F.

2.4 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. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.5 TAPES

A. ASJ and PVC Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Avery Dennison Corporation.
      b. Ideal Tape Co., Inc.
      c. Venture Tape.
      d. Approved equal.
   2. Width: 3 inches.
   3. Thickness: 11.5 mils.
   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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Avery Dennison Corporation.
   b. Ideal Tape Co., Inc.
   c. Venture Tape.
   d. Approved equal.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
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. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

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

   a. Avery Dennison Corporation.
   b. Ideal Tape Co., Inc.
   c. Venture Tape.
   d. Approved equal.

2. Width: 3 inches.
3. Thickness: 3.7 mils.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.6 SECUREMENTS

A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.

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

   a. Childers Products.
   b. PABCO Metals Corporation.
   c. RPR Products, Inc.
   d. Approved equal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, galvanized steel.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Childers Products.
   b. PABCO Metals Corporation.
   c. RPR Products, Inc.
   d. Approved equal.

PART 3 - EXECUTION

3.1 PREPARATION

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

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

3.2 GENERAL 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 mechanical staples and 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 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. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape 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.

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.

3.3 PENETRATIONS

A. Insulation Installation at Roof, Floor, Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through penetrations.

3.4 PENETRATIONS THROUGH FIRE-RATED ASSEMBLIES

A. Insulation Installation at Fire-Rated Wall and Partition Penetrations:
1. Duct: 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.

2. Pipe: Install insulation continuously through penetrations of fire-rated walls and partitions.

B. 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.

2. Pipe: Install insulation continuously through floor penetrations.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. For services not specified to receive a field-applied jacket except for flexible elastomeric, 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.

8. 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 in-line instruments, control valves, and unions. 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.

3.6 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.

3.7 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 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, 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: Secure with adhesive and insulation pins.

1. For ducts with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

2. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
3. 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.
4. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

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 ofducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

   1. Inspect ductwork, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to two location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
   2. Inspect pipe, fittings, strainers, and valves, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to two locations of straight pipe, two locations of threaded fittings, two locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, two locations of threaded valves, and two 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.

3.9 DUCT INSULATION SCHEDULE, GENERAL

A. Ducts and Terminal Devices Requiring Insulation:

   1. Indoor supply, return, outside, and exhaust-air ducts.
2. Diffuser backs.
3. Outdoor, exposed supply and return air.
4. Return-air plenums.

B. Items Not Insulated:

1. Factory-insulated flexible ducts.
2. Flexible connectors.
4. Factory-insulated access panels and doors.

3.10 INDOOR DUCT AND TERMINAL DEVICES INSULATION SCHEDULE

A. Interior Supply, Return, Outside, and Exhaust-Air Duct Insulation: Mineral-fiber blanket with factory-applied FSK Jacket, 2.2 inches thick and 0.75-lb/cu. ft. nominal density.

B. Interior Diffuser Backs Insulation: Mineral-fiber blanket with factory-applied FSK Jacket, 2.2 inches thick and 0.75-lb/cu. ft. nominal density.

C. Interior Return-Air Plenum Insulation: Mineral-fiber liner, 1 inch thick and 3-lb/cu. ft. nominal density.

3.11 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. Underground piping.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Hot Water and Hotwater Recirculation: Insulation shall be one of the following:

1. Flexible Elastomeric, Type I: ½ inch thick. Use for 120 deg F or less on lines that are roughed in at times when water infiltration during construction is possible.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick with factory-applied ASJ Jacket.

B. Domestic Cold Water: Insulation shall be the following:

1. Flexible Elastomeric, Type I: ½ inch thick.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick with factory-applied ASJ Jacket.
C. Exposed Sanitary Drains, Domestic Cold Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities: Insulation shall be the following:
   1. Install ADA acceptable guards as specified.

D. Condensate Drains: Insulation shall be the following:
   1. Flexible Elastomeric, Type I: ½ inch thick.

E. Refrigerant Hot Gas, Suction, and Liquid Piping: Insulation shall be the following:
   1. Flexible Elastomeric, Type I: 1 inch thick.

F. Storm Water and Overflow: Insulation shall be the following:
   1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1½ inch thick.

3.13 OUTDOOR PIPING INSULATION SCHEDULE
A. Refrigerant Hot Gas, Section, and Liquid Piping: Insulation shall be the following:
   1. Flexible Elastomeric, Type I: 2 inches thick.

3.14 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. Piping, Exposed:
   1. Polyguard; Alumaguard 60 (white in color).

D. Heating Hot Water Supply and Return: Insulation shall be the following:
   1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

END OF SECTION 230700
SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

   A. This Section includes, but is not limited to the furnishing of all material equipment and services necessary for the complete installation of a system of automatic temperature controls and monitor equipment for the following basic systems:

      1. Variable air volume rooftop HVAC equipment.
      2. Exhaust fans.
      3. Variable-air-volume terminal units.
      5. Variable refrigerant volume system.
      6. Collective protection system.
      7. Computer room air conditioning system.
      8. Condensing Boilers.
      9. Gas fired make-up air unit.

   B. Related Sections include the following:

      1. Section "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

   C. The HVAC controls system shall be one (1) complete system by one (1) unit manufacturer. System shall control both new and existing HVAC equipment. Building shall be controlled by single controls system.

1.3 DEFINITIONS

   A. ARP: Address Resolution Protocol.
   B. ASC: Application Specific Controller.
   C. BMS: Building Management System
   D. CAC: Custom Application Controller.
   E. CSMA/CD: Carrier Sense Multiple Access/Collision Detect.
   F. DDC: Direct Digital Control.
G. DDE: Dynamic Data Exchange.
H. FTT: Free Topology Transceivers.
I. GUI: Graphical User Interface.
J. HVAC: Heating, Ventilation, and Air Conditioning.
K. I/O: Input/Output.
L. LAN: Local Area Network.
M. MER: Mechanical Equipment Room.
N. ODBC: Open DataBase Connectivity.
O. PC: Personal Computer.
P. PES: Portable Engineering Station.
Q. PID: Proportional, Integral, Derivative.
R. POT: Portable Operator’s Terminal.
S. SQL: Structured Query Language.
T. TCC: Temperature Controls Contractor
V. UNC: Universal Network Controller.

1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
   a. Water Temperature: Plus or minus 10°F.
   b. Space Temperature: Plus or minus 1°F.
   c. Ducted Air Temperature: Plus or minus 1°F.
   d. Outside Air Temperature: Plus or minus 2°F.
   e. Dew Point Temperature: Plus or minus 3°F.
   f. Temperature Differential: Plus or minus 0.25°F.
   g. Relative Humidity: Plus or minus 5 percent.
   h. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
   i. Airflow (Terminal): Plus or minus 10 percent of full scale.
   j. Air Pressure (Space): Plus or minus 0.01-inch wg.
   k. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
   l. Electrical: Plus or minus 5 percent of reading.

1.5 SYSTEM DESCRIPTION

A. An ANSI/ASHRAE Standard 135-2004 BACnet distributed logic control system complete with all software and hardware functions shall be provided and installed. This system shall control all mechanical equipment, including all unitary equipment as specified using Native BACnet-compliant components. Non-BACnet compliant equipment or systems will not be acceptable.

B. The control system supplier shall provide a points list of all physical I/O points, analog object values and binary object values. The list shall include BACnet object number, BACnet device number, MAC address, device conformance level, data link layer utilized, and BACnet standard application services supported.

C. The network cabling is to be twisted shielded pairs. Cabling in air plenums are to be installed in conduit or be fire and smoke rated. Cabling installed in areas subject to damage are to be in conduit.

D. The system communications should be transparent, meaning that the user of the control program does not need to know the details of system architecture and operation.

E. Furnish all labor, materials, equipment programming, and service necessary for a complete and operating temperature control system, utilizing a high speed peer-to-peer network of interoperable Direct Digital Controls (DDC), Graphical User Interface (GUI) with color graphic displays available on at least 64 client computers, electronic interfaces and actuation devices, and as described in the contract documents. The number of user licenses shall be the same for Server Base, Client Base or Web Browser based software installations, thus providing a seamless installation and interface for the owner. No system shall be installed that is not capable of expansion without having to change out GUI, UNC or Controllers. System shall be required to have a minimum of 10% extra points available for future building needs without having to add expansion blocks. No systems that require a yearly licensing renewal fee to operate shall be permitted.

F. Note: Selected vendor shall work with plant IT department to secure open ports and IP addresses.
G. The Local Area Network (LAN) shall be either a 10 or 100 Mbps Ethernet network supporting ANSI / ASHRAE™ Standard 135-2004, Java, XML, HTTP, and CORBA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Universal Network Controllers (UNCs), user workstations and a local host computer system.

H. The Enterprise Ethernet (IEEE 802.3) LAN shall utilize Carrier Sense Multiple/Access/Collision Detect (CSMA/CD), Address Resolution Protocol (ARP) and User Datagram Protocol (UDP) operating at 10 or 100 Mbps.

I. The system will consist of an open architecture that utilizes BACnet distributed logic protocol as the common communication protocol between all controllers and integral ANSI / ASHRAE™ Standard 135-2004, BACnet functionality to assure interoperability between all system components and HVAC equipment. The ANSI / ASHRAE™ Standard 135-2004, BACnet protocol is required to assure that the project is fully supported by the leading HVAC open protocol to reduce future building maintenance, upgrade, and expansion costs.

J. All software programming and service tech tools shall be left with the owner including all cables and connectors required to network manage the ANSI / ASHRAE™ Standard 135-2004, BACnet protocol provided with the system. Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans, that is required to meet the functional intent, shall be provided without additional cost to the Owner. Full BACnet compliance programming, monitoring and control functions at user level with the ability to support data read and write functionality shall be provided. Physical connection of BACnet devices shall be via Ethernet/Ethernet IP.

1. The supplied system must incorporate the ability to access all data using non specific version of Java enabled browsers without requiring proprietary operator interface and configuration programs.

2. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage.
   a. This data shall reside on a supplier-installed server for all database access.
   b. Systems requiring proprietary database and user interface programs shall not be acceptable.
   c. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer’s internal Intranet network.
   d. Systems employing a “flat” single tiered architecture shall not be acceptable.

K. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of The Control Contractor. The Control Contractor shall have a minimum rated qualification of five (5) years of installation experience with the manufacturer and shall provide documentation in the bid and submittal package verifying longevity of the installing company's relationship with the manufacturer. Supervision, calibration and checkout of the system shall be by the employees of The Control Contractor.

L. Supplier shall have an in place support facility within 75 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.
M. The Contractor shall provide and mount a wall mounted notification (beacon and light) device within 911 Workstations 206 with a sign that reads “Communications 106 High Temperature Alarm”.

1.6 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

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. Bill of materials of equipment indicating quantity, manufacturer, and model number.

2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves and all other control devices.


4. Details of control panel faces, including controls, instruments and labeling.

5. Written description of sequence of operation and either:
   a. Programming ladder logic diagrams
   b. Control logic block diagrams, fully populated with initial setpoint and control values.

6. Schedule of dampers including size, leakage, and flow characteristics.

7. Schedule of valves including flow characteristics.

8. DDC System Hardware:
   a. Wiring diagrams for control units with termination numbers.
   b. Schematic diagrams and floor plans for field sensors and control hardware.
   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software:
   a. List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
   b. Hard copy of each graphic screen proposed.
10. Controlled Systems:
   a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
   b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
   c. Written description of sequence of operation including schematic diagram, and either:
      1) Programming ladder logic diagrams
      2) Control logic block diagrams, fully populated with initial setpoint and control values.
   d. Points list.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ANSI/ASHRAE Standard 134-2004 BACnet standards.

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

E. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

F. Qualification Data: For Installer and manufacturer.

G. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals as specified. Include the following:
   1. Maintenance instructions and lists of spare parts for each type of control device.
   2. Interconnection wiring diagrams with identified and numbered system components and devices.
   4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
   5. Calibration records and list of set points.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project. The Technician, Installer, or Graphics installer that starts the job is required to be the person that completes the job with no changes in personnel during the BMS installation. The manufacturer is to be ultimately responsible for the installation quality and warranty.
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. Bids by wholesalers and non-franchised contractors shall not be acceptable.

D. The system manufacturer shall, as a minimum, manufacture and supply the Custom Application Controllers, Application Specific Controllers, and Graphical User Interface.

E. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the direct employment of the temperature control system manufacturer.

F. Mechanical equipment manufacturers desiring to provide DDC type controls as factory-mounted equipment shall provide a separate bid for their products less all controls, actuators, valve assemblies and sensors, which are specified to be provided by the BMS contractor. All factory-mounted DDC controls in pre-package form shall be capable of interfacing with all BACnet protocol meeting ANSI / ASHRAE Standard 135-2004.

G. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems".


1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory-mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.9 COORDINATION

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

B. Coordinate with the Owner's IT department on locations for PC’s, UNC’s, Ethernet communication cabling and TCP/IP addresses.

1.10 WARRANTY AND MAINTENANCE

A. All components, system software, and parts furnished and installed by the BMS contractor shall be guaranteed against defects in materials and workmanship for one (1) year of substantial completion unless extended warranty by owner or manufacturer is greater than one (1) year. Labor to repair, reprogram, or replace these components shall be furnished by the BMS contractor at no charge during normal working hours during the warranty period. Materials furnished but not installed by the BMS contractor shall be covered to the extent of
the product only. Installation labor shall be the responsibility of the trade contractor performing
the installation. All corrective software modifications made during warranty periods shall be
updated on all user documentation and on user and manufacturer archived software disks. The
Contractor shall respond to the owner's request for warranty service within forty-eight (48)
standard working hours. Emergency service shall be available within two (2) hours.

1.11 OWNERSHIP OF PROPRIETARY MATERIAL

A. The owner shall sign a copy of the manufacturer’s standard software and firmware licensing
agreement as a condition of this contract. All software licensing shall be made to the owner and
not the contractor, vendor or installer with an all-tools-in all-tools-out function. Such license
shall grant use of all programs and application software to the owner as defined by the
manufacturer’s license agreement, but shall protect manufacturer’s rights to disclosure of trade
secrets contained within such software. All software shall be capable of adding other
manufacturer-licensed vendors if of the same firmware. All project developed software, control
software and documentation shall become the property of the owner. These include, but are not
limited to project graphic images, record drawings, project database, project specific
application programming code, and all other associated documentation.

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 CONTROL SYSTEM

A. Control system suppliers:

1. Only suppliers and vendors that can meet the requirements of guideline set forth will be
considered.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface
equipment, other apparatus, accessories, and software connected to distributed controllers
operating in multi-user, multitasking environment on token-passing network and programmed
to control mechanical systems. An operator workstation permits interface with the network via
dynamic color graphics with each mechanical system, building floor plan, and control device
depicted by point-and-click graphics.

2.3 BUILDING-LEVEL CONTROL SYSTEM

A. Manufacturers:
1. Alerton Controls.
2. Reliable Controls Corporation.
3. Trane.
4. Engineer’s Pre-Approved equal.

B. Other manufacturers not listed above may be acceptable with the following requirements:
   
   1. Manufacturer’s product meets the specified requirements other than the listed name.
   2. A written request for Engineer’s Pre-approval consideration must be received 9 days prior to bid date. Pre-approved Equals will only be accepted if Engineer lists the manufacturer by Addendum. NO APPROVALS WILL BE CONSIDERED IF A WRITTEN REQUEST IS NOT RECEIVED 9 DAYS PRIOR TO BID DATE.

2.4 DDC EQUIPMENT

A. Workstation server hardware station: IBM-compatible microcomputer with minimum configuration as follows:

2. Chassis Type: 1U rack-optimized chassis or desktop server as requested by owner.
3. Processor: Intel Core 2 Duo 6700 or better.
4. Memory: One (1) 4GB PC6700 DDR2 4x1GB module or two (2) 2x2GB modules.
5. First Expansion Slot Riser: One (1) Low-Profile 64-bit PCI-X or equal.
7. Hard Drive: Total three (3), SATA 7200RPM 250GB minimum each. One (1) HDD allocated for the OS and two (2) HDD’s in a RAID 1 configuration.
8. Hot-Swap SATA Drive Upgrade: Three (3) Hot-Swap SATA drive support.
9. RAID Card: one (1) LSI MegaRAID 150-6 SATA PCI 64/66 RAID Controller.
10. Standard Disk Controller: one (1) Integrated dual port SATA controller (supports embedded RAID 0/1).
11. USB: minimum of four (4) USB ports.
12. DVD –CD ROM Drive: one (1) Single Drive 16X CD/DVD burner (DVD+/- RW) w/double layer write capability.
13. Server Management: Gateway Systems Manager (or equal).
15. Network Card: Dual PCI 10/100/1000 Twisted Pair Ethernet.
16. Extended : Warranty: Two (2) year parts and labor one (1) year on-site service.
17. Rack Accessories: Tool-less slide rails and Cable Management Arm.

B. A UPS (un-interruptible power supply) shall be installed at the server site for 50% spare capacity with sufficient capacity to allow emergency power for a minimum of 10 minutes backup.

C. Provide printer color; ink-jet type.

1. Print Head; 1440 c 1440 dpi photo quality color resolution.
   a. Internal Memory Buffer: 32KB
b. Paper Handling: Minimum 100 Sheets

c. Print Speed: Minimum of 8 ppm in black and 4 ppm in color.

D. Table for controls workstation.

E. Control units general.

1. Provide an adequate number of control units to achieve monitoring and control of all data points specified and necessary to satisfy the sequence of operation for all mechanical systems shown on the plans. Provide a minimum of one separate controller for each outside air unit or other HVAC system. Multiple DDC controllers may control one system provided that all points associated with individual control loops are assigned to the same DDC controller.

Points used for control loop reset such as outside air or space temperature are exempt from this requirement. Each of the following panel types shall meet the following requirements.

2. Controllers shall be suitable for the anticipated ambient conditions.

   a. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at -40°F to 140°F and 5 to 95% RH, non condensing.

   b. Controllers used in conditioned ambient space shall be mounted in dustproof enclosures, and shall be rated for operation at 32°F to 122°F and 5 to 95% RH, non-condensing.

3. Serviceability: Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

4. Memory: The Control Units shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

5. Diagnostics: The Building Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall assume a predetermined failure mode and generate an alarm notification.

6. Immunity to power and noise: Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.

7. Automatic staggered restart of field equipment after restoration of power and short cycle protection.

F. Universal network controllers (UNC).

1. The Universal Network Controllers (UNC) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the UNC. It shall be capable of executing application control programs to provide:

   a. Calendar functions.

   b. Scheduling.

   c. Trending.

   d. Alarm monitoring and routing.
2. The universal network controller must provide the following hardware features as a minimum:
   
a. One Ethernet Port – 10/100 Mbps.
b. Two RS-232 ports.
c. Two RS-485 ports electrically isolated.
d. One BACnet Interface Port.
e. Power supply 24 VAC or 24 VDC.
f. Battery Backup.
g. Real-time clock.
h. Processor @ 200 MHz or greater.
i. 8 Mb flash memory for long term data backup. If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity.
j. 64 Mb Ram or greater.

3. The UNC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the UNC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.

4. The UNC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 64 simultaneous users.

5. Event Alarm Notification and actions.
   
a. The UNC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
b. The UNC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
c. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:

   1) To alarm.
   2) Return to normal.
   3) To fault.

d. Provide for the creation of a minimum of eight alarm classes for the purpose of routing types and/or classes of alarms, i.e. HVAC, fire, etc.
e. Provide timed (schedule) routing of alarms by class, object, group, or node.
f. Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
g. Control equipment and network failures shall be treated as alarms and annunciated.
h. Alarms shall be annunciated in any of the following manners as defined by the user:
1) Screen message text.
2) Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
   
   a) Day of week.
   b) Time of day.
   c) Recipient.

   i. Pagers via paging services that initiate a page on receipt of email message.
   j. Graphic with flashing alarm object(s).
   k. Printed message, routed directly to a dedicated alarm printer.
   l. The following shall be recorded by the UNC for each alarm (at a minimum):
      
      1) Time and date.
      2) Location (building, floor, zone, office number, etc.).
      3) Equipment (air handler #, access way, etc.).
      4) Acknowledge time, date and user who issued acknowledgement.
      5) Number of occurrences since last acknowledgement.

   m. Alarm actions may be initiated by user defined programmable objects created for that purpose.
   n. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
   o. A log of all alarms shall be maintained by the UNC and/or a server (if configured in the system) and shall be available for review by the user.
   p. Provide a “query” feature to allow review of specific alarms by user defined parameters.
   q. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
   r. An error log to record invalid property changes or commands shall be provided and available for review by the user.

6. Data collection and storage.

   a. The UNC shall have the ability to collect data for any property of any object and store this data for future use.
   b. The data collection shall be performed by log objects, resident in the UNC that shall have, at a minimum, the following configurable properties:
      
      1) Designating the log as interval or deviation.
      2) For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
      3) For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
      4) For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
      5) Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
7. All log data shall be stored in a relational database in the UNC and the data shall be accessed from a server (if the system is so configured) or a standard Web Browser.

8. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

9. All log data shall be available to the user in the following data formats:
   a. HTML.
   b. XML.
   c. Plain text.
   d. Comma or tab separated values.

10. Systems that do not provide log data in HTML and XML formats at a minimum shall provide as an alternative Microsoft SQL Server, Oracle 8i or Express, Hyperion Solutions™ SQL Server.

11. The UNC shall have the ability to archive its log data either locally (to itself), or remotely to a server or other UNC on the network. Provide the ability to configure the following archiving properties, at a minimum:
   a. Archive on time of day.
   b. Archive on user-defined number of data stores in the log (buffer size).
   c. Archive when log has reached its user-defined capacity of data stores.
   d. Provide ability to clear logs once archived.

12. Audit log.
   a. Provide and maintain an Audit Log that tracks all activities performed on the UNC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the UNC), to another UNC on the network, or to a server. For each log entry, provide the following data:
      1) Time and date.
      2) User ID.
      3) Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

13. Database backup and storage.
   a. The UNC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
   b. Copies of the current database and, at the most recently saved database shall be stored in the UNC. The age of the most recently saved database is dependent on the user-defined database save interval.
   c. The UNC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

G. Custom application control units.

1. Modular, comprising processor board with programmable, nonvolatile, RAM/EEPROM memory for custom control applications. CAC’s shall be provided for outside air units,
boilers, fluid cooler and other applications as shown on drawings and shall have published BACnet application source code, device resource files and external interface definitions.

2. Units monitor ad/or control each input/output point; process information; and at least 50 expressions for customized HVAC control including mathematical equations, Boolean logic, PID control loops with anti-windup, sequencers, timers, interlocks, thermostats, enthalpy calculation, counters, interlocks, ramps, drivers, schedules, calendars, OSS, compare, limit, curve fit, and alarms.

3. Stand-alone mode control functions operate regardless of network status. Functions include the following:
   a. Peer-to-peer primary network level communications.
   b. Automatic communications loss detection to maintain normal control functionality regardless of available network communications.
   c. Discrete/digital, analog, and pulse input/outputs.
   d. Monitoring, controlling, or addressing data points.
   e. Local energy management control strategies.
   f. Incorporate internal customizable safeties and limits to prevent improper and unrealistic inputs to CAC’s.
   g. Local operator interface port provides for download from and connection to portable workstation.

4. Communication: The Custom Application Controller shall communicate via the Primary Controller Network between BMS Controllers and other BACnet devices. CAC’s shall communicate with the Building Controller and ASC’s at a baud rate of not less than 78.8K baud using BACnet communications protocol.

H. Application specific control units:

1. Single board construction comprising processor board with programmable, nonvolatile, RAM/EEPROM memory for custom control and unitary applications. ASCs shall be provided for water-source heat pumps and other applications as shown on the drawings.

2. Units monitor or control each input/output point; process information; and download from the operator station.

3. Stand-alone mode control functions operate regardless of network status. Functions include the following:
   a. Peer-to-peer primary network level communications with automatic communications loss detection to maintain normal control functionality regardless of available network communications.
   b. Discrete/digital, analog, and pulse input/output.
   c. Monitoring, controlling, or addressing data points.
   d. Appropriate set-points for specific unitary applications.
   e. Internal customizable safeties and limits to prevent improper and unrealistic inputs to ASC’s.

4. Local operator interface port located on ASC and ASC sensor to provide for download from or upload to portable workstation. All bus devices shall be accessible from either port.
5. Communication: ASC’s shall communicate with the Building Controller and CAC’s at a baud rate of not less than 78.8K baud using BACnet communications protocol.

I. ASC room sensor.

1. The ASC Sensor shall provide room temperature value to the ASC.
2. The ASC Sensor shall connect directly to the ASC and shall not utilize any of the I/O points of the controller.
3. The ASC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive.
4. There shall be one ASC Sensor per floor wired so that the communication jack will provide for a connection to the BACnet communication trunk to which the ASC controller is connected.
5. By connecting to this ASC Sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the Portable Engineering Station.
6. The ASC Sensor shall be supplied in the following manner:
   a. LCD display for viewing up to four possible displays, each showing a current value in the ASC or on the network.
   b. Tenant override to allow timed override of unoccupied to occupied mode of operation.
   c. LED indication of override state.
   d. The room sensor shall provide access to additional diagnostic data from a sensor-user keypad request. This Diagnostic mode is displayed on the LCD screens and includes separate displays for the controllers:
      1) Subnet and Node Address
      2) Errors
      3) Alarms
      4) Temperature Offset

J. ASC – water-source heat pump controller functionality.

1. Controls shall be microprocessor based as shown in the drawings or indicated in the sequence of operations. The ASC shall be a single integrated package consisting of a microprocessor, power supply, field terminations, and application software. The units shall be started and stopped from the BMS. All input/output signals shall be directly hardwired to the ASC controller. In all cases, the controller shall automatically resume proper operation following the return of power to, or control by the ASC.
2. All ASCs must have an operating temperature range -40°F to 140°F and 5 to 95% RH, non-condensing because they are located in the proximity of extreme temperatures.
3. All duct averaging sensors for ASCs must be true continuous averaging units that sense the mean temperature over the complete length of the sensor end to end. Sensors that provide four or nine sensing points, which may not be accurate due to air temperature stratification, are not acceptable.
4. All ASCs shall be easily replaceable for ease of future maintenance and to minimize downtime.
5. The outputs of the ASC shall be of the relay Form C and universal analog form. All digital outputs shall be relay type Form C. ASC devices utilizing non-relay outputs shall provide an interface relay for all points. All analog outputs shall be programmable for their start points and span to accommodate the control devices.
K. LANs:

1. Capacity for a minimum of 64 client workstations connected to multi-user, multi-tasking environment with concurrent capability to access DDC network or control units.

2. Enterprise network LAN:
   a. Media: Ethernet (IEEE 802.3), peer-to-peer CSMA/CD, operating at 10 or 100 Mbps, cable 10 Base-T, UTP-8 wire, category 5

3. Primary controller network LAN:
   a. Media: BACnet, peer to peer.

4. Secondary network LAN (if required):
   a. Media: BACnet, peer to peer.

5. Remote connection:
   a. SDN, ADSL, or T1 (service provided by building owner)

L. Software:

1. Controller and system HVAC applications update to latest version of software at project completion. Include and implement the following capabilities from the control units if documented by the specified sequence of operations.

2. Controller and network setup software:

2.5 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor temperature sensors and transmitters.

1. Manufacturers:
   a. BEC Controls Corporation.
   b. Ebtron, Inc.
   c. Heat-Timer Corporation.
   d. I.T.M. Instruments Inc.
   e. MAMAC Systems, Inc.
   f. RDF Corporation.
   g. Reference section 2.2.A "Control System Supplier".

2. Accuracy: Plus or minus 0.5° F at calibration point.

4. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.

5. Averaging Elements in Ducts: 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.


C. Pressure transmitters/transducers:

1. Manufacturers:
   a. BEC Controls Corporation.
   b. General Eastern Instruments.
   c. MAMAC Systems, Inc.
   d. ROTRONIC Instrument Corp.
   e. TCS/Basys Controls.
   f. Vaisala.
   g. Reference section 2.2.A "Control System Supplier".

2. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated.
   a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   b. Output: 4 to 20 mA.
   c. Building Static-Pressure Range: 0- to 0.25-inch wg.
   d. Duct Static-Pressure Range: 0- to 5-inch wg.

3. Water pressure transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.

4. Water differential-pressure transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.

5. Differential-pressure switch (air or water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

6. Pressure transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.6 STATUS SENSORS

A. Status inputs for fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status inputs for electric motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

C. Current switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
D. Electronic valve/damper position indicator: Visual scale indicating percent of travel and feedback signal.

2.7 HUMIDITY SENSORS

A. Manufacturers:

1. ACI.
2. BEC Control Corp.
4. MAMAC Systems Inc.
5. Re Technologies.
6. TCS/Basys Controls.
7. Approved equal.

B. Humidity sensors shall be capacitance or bulk polymer resistance type.

C. Duct and room sensors shall have a sensing range of 20 to 80% with accuracy of +/- 5% R.H. Duct sensors shall be provided with a sampling chamber.

D. Outdoor air and high limit humidity sensors shall have a sensing range of 20 to 95% R.H. It shall be suitable for ambient conditions of -40°F to 170°F.

2.8 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in other Division 27 Sections.

2.9 CONTROL PANELS

A. Local Control Panels: Unitized NEMA 1 cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.

2.10 EMERGENCY SHUTOFF SWITCHES

A. Manual override switch. Switch shall be a red mushroom style button with manual reset. Switch shall be located in a clear plastic box to prevent accidental contact. The box shall NOT be lockable.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that power supply is available to control units and operator workstation.

3.2 INSTALLATION
A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, other exposed control sensors and control units with drawings and room details before installation. Install devices in accordance with the KBC and ADA for handicap accessibility.
   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install automatic dampers according to Section "Duct Accessories."

E. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

F. Install labels and nameplates to identify control components according to Section "Mechanical Identification."

G. Install duct volume-control dampers according to Sections specifying air ducts.

H. Provide clear and thorough Owners Manuals with extensive diagrams and examples. Also provide documentation such as installation drawings and software documentation.

I. Provide operational information on the system. This will include file drawings and framed schematics and operation sequences posted in the area.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install building wire and cable according to other applicable Sections.

B. Install signal and communication cable according to the following:
   1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway.
   3. Install concealed cable in raceway.
   4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
   5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Connections, switches, LED’s, major components, etc. inside the enclosures are to be labeled in the unit.

D. Connect manual-reset limit controls independent of manual-control switch positions.
E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 ADJUSTING

A. Calibrating and adjusting.

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control system inputs and outputs:
   a. Check analog inputs at 0, 50, and 100 percent of span.
   b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
   c. Check digital inputs using jumper wire.
   d. Check digital outputs using ohmmeter to test for contact making or breaking.
   e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
   a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
   b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
   a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
   b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
   a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistant source.
   b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.
3.5 DEMONSTRATION

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

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs. Include a minimum of twenty-four (24) hours dedicated instructor time on-site.
3. Review data in maintenance manuals as identified in "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.6 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three (3) project site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

3.7 TRAINING

A. Provide a minimum of twenty-four (24) hours of on-site or classroom training throughout the contract period for personnel designated by the Owner. Each session shall be a minimum of four (4) hours in length and must be coordinated with the building Owner. Train the designated staff of Owners Representative and Owner to enable them to:

1. Proficiently operate the system.
2. Understand control system architecture and configuration.
3. Understand DDC system components.
4. Understand system operation, including DDC system control and optimizing routines (algorithms).
5. Operate the workstation and peripherals.
6. Log on and off the system.
7. Access graphics, print reports, and logs.
8. Adjust and change system set points, time schedules, and holiday schedules.
9. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals.
10. Understand system drawings, and Operation and Maintenance manual.
11. Understand the job layout and location of control components.
13. Operate portable operators' terminals.

END OF SECTION 230900
Shelter-In-Place
System Overview

I. Overview

The Shelter-In Place Project at the Madison County EMA Office, located at 560 S. Keenland Drive, Richmond, KY 40475, was constructed to allow the facility to continue working in the event of a Chemical Agent Release. The system is designed to be activated by a single push of the "red" button on the control panel, located inside the Mechanical Room, on the east end of the first floor.

When the "red" button is pressed, the control panel will begin to light up green when each piece of equipment is activated. The system will simultaneously activate all equipment. While some equipment will take longer to activate than others, all lights on the panel should be on in approximately one minute.

II. HVAC

The Government furnished VFD, Emanon AHU-F and Carrier CU-F, are located in the mechanical yard located at the south end of the building. These pieces of equipment receive power from the MDP panel, breaker A.H.U.F. located in the Electrical Room, thru the service disconnect located outside. The disconnect feeds the pad mounted transformer and an additional panel that supplies power to the VFD, AHU-F and CU-F.

The AHU-F has a series of filters to include: Pre-Filters, Hepa Filters and Carbon Absorbers. Additional information on the Pre and Hepa filters is located on Sheet Number C-3 of the As-built Drawing and also in the O&M Manual on under Flanders Rigid Air Filters and Flanders Hepa Filters section.

When the emergency system is activated, the Variable Frequency Drive will turn on the AHU-F and pressurize the building. When...
the air pressure switch on the output duct of the AHU is closed, the thermostat inside the building will either activate the heating or cooling system. Automatic controls in the AHU-F will control the output temperatures of the air handler. The settings are 90 degrees Fahrenheit for heat and 55 degrees Fahrenheit for cooling.

The AHU-F supplies filtered air through the duct work that runs up the exterior building to the roof top, above the Apparatus Bay, and ties into Damper 009(D9). This damper is Normally Closed and switches to Emergency Open when the system is activated.

Dampers 005(D5), 006(D6) and 007(D7) are inside of the main AHU-1 located on the 2nd floor roof top. These dampers are Normally Open and switch to Emergency Closed when the system is activated. Damper 004(D4) and Exhaust Fan 2(EF-2) are also located on the 2nd floor roof top above the restrooms. When the system is activated the Exhaust Fan (EF-2) and 004 will switch from Normally Open to Emergency Closed and EF-2 will de-energize. This roof top can be accessed by using the roof ladder located at the top of the staircase.

Damper 008 and Exhaust Fan 5 (EF-5) are located on the 2nd floor in the kitchen above the ceiling to the right of the stove. EF-5 is the hood exhaust. When the system is activated, the damper will switch from Normally Open to Emergency Closed and the Exhaust Fan will de-energize.

Damper 002 and Exhaust Fan 1(EF-1) are located on the 1st floor roof top above the restrooms. When the system is activated, the damper will go from Normally Open to Emergency Closed and EF-1 will de-energize. This roof top will have to be accessed from an extension ladder.

Damper 001 is located in the 1st floor mechanical room, in the outside air line. It is also accessible from either inside or out.

III. Doors

The perimeter protection doors are equipped with automatic door bottoms and magnetic door locks. When the system is activated the Magnetic lock will activate. If a green light does not come
on for one of the doors, check to make sure the Maintenance Door Lock switch, located at the bottom right of the control panel, is in the “On” position. If the switch is the correct position, visually check to make sure the door is completely closed. The door locations are identified on the maps in Section 3. The maintenance switch can be used to de-activate the magnets on the doors when performing inspections. A button has also been added to the right side of the front desk that will allow power to be temporarily broken to Main Door 2. The Automatic Door Bottoms can be adjusted by turning the brass knob on the hinge side of door bottom. This will change the depth that the automatic bottom will deploy.

The following is purchasing information for the Magnetic Locks and the Automatic Door Bottoms:

Automatic Door Bottoms:

Zero International
415 Concord Avenue
Bronx, NY 10455
Tel: 718.585.3230
Part No. 367

Magnetic Locks:

Dorma Entrance Systems & Dorma Automatics
Tel: 877.367.6211
Part No. EML011M  628
Power Supply 502RF

IV. Space Air Pressure

The space air pressure reading on the control panel should read between 0.190 and 0.205 when system is in operation. The space pressure devices are a small diameter black tube that penetrates the ceiling grid in the locations identified on the map. The
tube goes back to the control panel to the GE Sensing T 30 pressure transmitter. Space 1 reads pressure of the 1st floor and space pressure 2 provides a reading from the 2nd floor.

V. Auxiliary Power.

The Shelter-in place system is supported by a back-up generator in the event of a power failure. A switch to manually test the generator is located in the mechanical room by the MDP Breaker Panel.

VI. Electrical

The Service Disconnect Located in the Mechanical yard is a Square D 600Vac, 600Vdc, item HU364RB, single throw non-fusible safety switch. The disconnect is supplied from panel MDP located in the Electrical Room. The Disconnect then supplies a Square D, 3 phase, 75KVA, 480/208 Non-Ventilated Transformer. Catalog Number 75T3HISCUNV. The Transformer then supplies a Square D, NQ Panel Board. From the Transformer, Power is supplied to the VFD, CU-F and AHU-F.
Madison County EOC
Richmond, Kentucky
January 24, 2014

Murphy + Graves Architects
Project No. 1308
EXISTING COLLECTIVE PROTECTION SYSTEM OVERVIEW

230900A - 6
FEMA DESIGN SUPPORT FOR MADISON COUNTY, KENTUCKY
MADISON COUNTY EMA BUILDING
W912QR-08-C-0062

EQUIPMENT LIST

Government Furnished Equipment

1) Air Filtration System (AHU-F):
   EMANON Air Handling Unit Air Filtration System
   a) Supply Fan:
      Greenheck Model 18 PLN
   b) Heating Section:
      REZNOR Model HRPD-600
   c) Cooling Coil:
      DX Evaporated Coil
      HeatCraft Model AC0SEJ1104C39045281315

2) Condensing Unit:
   30 Ton Air Cooled Condensing Unit
   Carrier Model 388AH034

Contractor Furnished Equipment

1) LG MINI-SPLIT
   Model: LSU122HE

2) Control Dampers:
   United Enertech
   Model: CD-150(Opposed)

3) Flanders Rigid-Air Pre-Filters
   Model: PB1001-0408

4) Flanders Filters for Hepa Filters
   Model: 0-011-H-08-03-SU-12-11-209093

5) Square D: Safety Switch
   Model: HU364RB
6) Square D: 75 kva 480/208v Pad Mounted Transformer
   Catalog No. 7ST3HISCUNV

7) Square D: NQ Panel boards
   Class 1640

8) Dorma Magnetic Locks
   EML-1000M Series

9) Red lion
   Model CUB3L & CUB3LR

10) GE: Sensing
    Pressure Transmitters Series T30

11) Kele DC Power Supplies
    Model DCP 1.5W
Damper 001 located in Mechanical Room
Damper 002 and EF-1
Damper 004 and EF-2
Damper 008 and EF-5 located in kitchen
Damper 009
Mechanical Yard
Roof Top Mini Split CU

Mini Split is located in the 2nd floor Server Room
Space Pressure 1

Space Pressure 2

END OF SECTION 230900A
SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes control sequences for HVAC systems, subsystems, and equipment.
   B. See Section "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.
   C. HVAC Controls Schedule of Set-points.

1.2 VARIABLE-AIR VOLUME HVAC UNITS CONTROLS SEQUENCES (RTU-1, 2)
   A. Unoccupied Operation – In the unoccupied mode, the unit shall be shut off. If the space temperature as sensed by a single zone sensor falls below or rises above the unoccupied set-point, the compressor, fans, natural gas valve and heat exchanger shall be energized based on the need for either heating or cooling until the unoccupied set-point is reached. Outside air damper shall be closed during unoccupied hours.
   B. Transition from Unoccupied to Occupied – When the HVAC unit transitions from the unoccupied mode to the occupied mode, morning warm-up or morning cool-down shall be activated.
      1. Morning Warm-Up – When there is a call for heating and the temperature is -2°F off set-point, a morning warm-up shall be initiated. The gas valve, heat exchanger and fans shall be shall be energized. When the zone temperature reaches the heating set-point, the unit shall operate in the occupied mode.
      2. Morning Cool-Down – When there is a call for cooling and the zone temperature is +2°F off set-point, a morning cool-down shall be initiated. The compressor and fan shall be turned on and the reversing valve shall be energized. When the zone temperature reaches the cooling set-point, the unit shall operate in the occupied mode.
   C. Occupied Operation – In the occupied mode, the unit evaporator fan shall run continuously changing speed dependent of supply duct pressure. If the space temperature, relative humidity, as sensed by a return air sensor rises above the occupied set-points, the compressor and fan shall be energized based on the need until the set-points are satisfactory. If space temperature as sensed by a return air sensor or leaving air temperature drops below 50°F, gas heating system shall be shall be energized based on the need until the set-points are satisfactory. The outside-air damper shall be capable of 100% modulation to provide minimum outside air flow rate as specified on drawings or allow equipment to operate in economizer mode when outdoor temperature is below set-point specified on drawings. A duct-mounted humidity sensor shall control the dehumidification operation. The modulating hot gas reheat system shall be controlled to maintain the target relative humidity. Except for the modulating hot gas reheat operation, the cooling and heating operations shall be configured to not operate simultaneously.
D. Shelter-In-Place Operation: When any of the emergency shutoff switches are activated in the building, the ventilation air dampers on units tagged RTU-1 and RTU-2 shall close 100%. The dampers shall not be allowed to open until all emergency shutoff switches have been manually reset. When an emergency shut off switch has been activated, a signal shall be sent to the BMS to alert an Owner designated personnel the Shelter-In-Place system has been activated. Refer to the drawings for the location of the emergency shutoff switches.

E. Operator Interface: Indicate the following on the operator workstation display terminal:
   a. System graphic.
   b. System occupied/unoccupied mode (separate scheduling ability) indication operates from 7:00 a.m. to 5:00 p.m., (adjustable).
   c. System on-off indication.
   d. System fan on-off command and status indication.
   e. VAV fan speed and CFM output.
   f. System compressor(s) on-off command and status indication.
   g. System modulating hot-gas reheat (dehumidifying) command and status indication.
   h. Outside air temperature indication.
   i. Occupied set-point temperature, 70°F cooling/ 68°F heating (adjustable).
   j. Space temperature indication.
   k. Space relative humidity set-point, 50% (adjustable).
   l. Discharge air temperature indication.
   m. Alarm output for failure.
   n. Outside and return damper positions.
   o. Gas heating on-off command and status indication.
   p. Power exhauster on-off command and status indication.
   q. Economizer on-off command and status indication.

1.3 VARIABLE-AIR VOLUME SINGLE DUCT BOXES

A. Unit Control:
   1. Occupied Operation – In the occupied mode, the unit’s air damper shall modulate to maintain space temperature setpoint. If the space temperature, as sensed by the zone sensor, falls below or rises above the occupied set-point, the air handler fan, heating hot water pumps, and three way control valve shall be energized based on the need for either heating or cooling until the occupied set-point is reached.
   2. Operator Interface: Indicate the following on operator workstation display terminal:
      a. System graphic.
      b. System on-off indication.
      c. System heat or cool command and status indication.
      d. Control valve position (3-position).
      e. Air damper position (% open).
      f. Space temperature indication.
      g. Occupied heating set-point indication (adjustable).
      h. Occupied cooling set-point indication (adjustable).
      i. Room temperature set-point high and low limits indication, set ± 2°F bias, (adjustable).
      j. Discharge air temperature indication.
k. Alarm output for failure (including onboard safeties).

1.4 HYDRONIC BOILERS CONTROL SEQUENCES (B-1, B-2, and B-3)

A. Unit Control (Temperature Controls Contractor (TCC) shall completely integrate the boiler system control for the BMS):
   1. Building BMS system shall interface with the boiler manufacturer-supplied control panel.
   2. Secondary loop pump shall be interlocked with boiler(s) operation to maintain heating water temperature as specified by boiler manufacturer. Circulator pumps (P-2A, P-2B, and P-2C) shall not run unless boiler is in operation.
   3. Boiler shall have temperature reset control as specified by the manufacturer that shall be initiated by outdoor ambient air temperature.

B. Unit Schedule:
   1. Occupied Operation – Boilers shall operate continuously on a call for heating and shall modulate firing rate based on system heating demand.

C. Operator Interface: Display the following data:
   1. System Graphic.
      a. Display boiler system outputs.
      b. Interface boiler system input/variables.
      c. Loop supply temperature indication.
      d. Loop return temperature indication.
      e. Operating command of boiler.
      f. Status of boiler:
         1. Entering water temperature (°F).
         2. Leaving water baseline temperature (60°F, adjustable).
         3. Leaving water reset temperature (80°F, adjustable).
         4. Reset ambient air temperature (0°F, adjustable).
      g. Alarm for boiler failure.

D. Provide Lead/lag control and automatic duty switching for boiler run times.

1.5 HYDRONIC PUMPS CONTROL SEQUENCES (P-1A and P-1B)

A. Unit Control:
   1. Pumps shall be started, through their on-off-auto selector switches, by the BMS.

B. Unit Schedule:
   1. Occupied Operation – Pumps shall operate continuously on a call for heating.

C. Operator Interface: Display the following data:
1. System Graphic.
2. Operating command of pump.
3. Alarm for pump failure.
4. Provide Lead/lag control and automatic duty switching for pump run times.

1.6 HYDRONIC PUMPS CONTROL SEQUENCES (P-2A, P-2B and P-2C)

A. Unit Control:

1. Pumps shall be interlocked with respective boiler operation. Building BMS system shall monitor unit operation.

B. Unit Schedule:

1. Unit shall only operate when boiler is activated for heating. Pump shall start prior to boiler coming online to ensure boiler does not fire on a dry heat exchanger.

C. Operator Interface: Display the following data:

1. System graphic.
2. Status of pump. Current transmitter(s) are required.
3. Alarm for pump failure.

1.7 VARIABLE REFRIGERANT VOLUME CONTROL SEQUENCES

A. Unit Control:

1. Unoccupied Operation – In the unoccupied mode, the unit shall be shut off. If the space temperature as sensed by the zone sensor mounted within the thermostat falls below or rises above the unoccupied set-point, the compressor(s), reversing valve, and fan shall be energized based on the need for either heating or cooling until the unoccupied set-point is reached.

2. Transition from Unoccupied to Occupied – When the terminal unit transitions from the unoccupied mode to the occupied mode, morning warm-up or morning cool-down and random start programs shall be activated.

   a. Morning Warm-Up – When there is a call for heating and the zone temperature is -2°F off set-point, a morning warm-up shall be initiated. The compressor(s), reversing valve, and the fan shall be energized. When the zone temperature reaches the heating set-point, the unit shall operate in the occupied mode.

   b. Morning Cool-Down – When there is a call for cooling and the zone temperature is +2°F off set-point, a morning cool-down shall be initiated. The compressor(s), reversing valve, and fan shall be energized. When the zone temperature reaches the cooling set-point, the unit shall operate in the occupied mode.

   c. Random Start – Random start of the unit is intended to prevent all units in a building from energizing major loads at the same time. The compressor(s) reversing valve, and fan shall be delayed from 3 to 32 seconds when power has been either restored after a loss or outage, or after the unit is enabled. A random number generator in software shall be used to generate the delay.
3. Occupied Operation – In the occupied mode, the unit fan shall run as required to satisfy the zone temperature requirements. If the space temperature, as sensed by the zone sensor mounted within the thermostat, falls below or rises above the occupied set-point, the compressor(s) and reversing valve shall be energized based on the need for either heating or cooling until the occupied set-point is reached.

4. Override Operation – When override is depressed in a room, the terminal unit shall operate as if in occupied mode.

B. Operator Interface: All points available from the variable refrigerant volume manufacturers shall be integrated into the building automation system.

1.8 COMPUTER-ROOM AIR CONDITIONER CONTROL SEQUENCES

A. Unit Control:
   1. Space temperature and humidity shall be communicated to the BAS via a dedicated zone sensor in the space served by the computer-room air conditioner.
   2. The space temperature and humidity shall be out of range for at minimum five (5) minutes, adjustable, prior to initiation of alarm.

B. Operator Interface: Display the following data:
   1. System graphic.
   2. System on-off indication.
   3. System fan on-off command and status indication.
   4. System compressor on-off command and status indication.
   5. Space temperature (°F).
   7. Space humidity (% RH).
   8. Space humidity setpoint (adjustable).
   9. Alarm for all onboard safeties.
   10. Alarm if space temperature exceeds a range of 60° F to 80° F, (Adjustable).
   11. Alarm if space humidity exceeds a range of 40% to 60% RH, (Adjustable).

END OF SECTION 230993
SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Hot-water heating piping.
2. Condensate-drain piping.
3. Air-vent piping.

1.2 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Hot-Water Heating Piping: 150 psig at 200 deg F.
2. Condensate-Drain Piping: 150 deg F.
3. Air-Vent Piping: 200 deg F.

1.3 SUBMITTALS

A. Product Data: For each type of the following:

1. Pipe and fittings.
2. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
4. Hydronic specialties.

B. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Wrought-Copper Fittings: ASME B16.22.

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

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

B. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

C. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

2.3 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:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      c. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.
      d. Approved equal.

   2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Calpico, Inc.
      b. Lochinvar Corporation.
      c. Approved equal.

   2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
2.4 VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump; a division of ITT Industries.
   c. Flow Design Inc.
   d. Griswold Controls.
   e. Approved equal.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
8. Handle Style: Lever, with memory stop to retain set position.
10. Maximum Operating Temperature: 250 deg F.

2.5 HYDRONIC PIPING SPECIALTIES

A. 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 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 3 and smaller, shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

B. Condensate-Drain Piping: Above ground NPS 2 and Smaller, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

C. Air-Vent Piping:
1. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

3.2 VALVE APPLICATIONS
A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.
B. Install throttling-duty valves at each branch connection to return main.
C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

3.3 PIPING INSTALLATIONS
A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
E. Install piping to permit valve servicing.
F. Install piping at indicated slopes.
G. Install piping free of sags and bends.
H. Install fittings for changes in direction and branch connections.
I. Install piping to allow application of insulation.
J. Select system components with pressure rating equal to or greater than system operating pressure.
K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
L. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
M. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
N. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the side of the main pipe.
O. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

P. Install strainers on inlet side of each control valve, coil, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

Q. Identify piping as to contents and flow direction.

3.4 HANGERS AND SUPPORTS

A. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal piping.
   2. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

B. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

C. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE 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. 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. 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.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at all high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Supply and return piping connections shall sized for flow rate not equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections.

3.8 CHEMICAL TREATMENT

A. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

3.9 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum
yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
3. Set temperature controls so all coils are calling for full flow.

END OF SECTION 232113
SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:


1.2 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.

C. Operation and maintenance data.

1.3 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. UL Compliance: Comply with UL 778 for motor-operated water pumps.

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. Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers:

1. Armstrong Pumps Inc.
2. Bell & Gossett.
3. Patterson.
4. Approved equal.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.

C. Pump Construction:
1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings.

D. Motor: Provide with grease-lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing. Include built-in, thermal protection. Select motor to be non-overloading over full range of pump performance curve.

PART 3 - EXECUTION

3.1 PUMP INSTALLATION
A. Comply with HI 1.4.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Suspend in-line pumps with continuous-thread rods and spring hangers with vertical-limit stop.

3.2 CONNECTIONS
A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install Y-type strainer on suction side of in-line pumps.
F. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping.

END OF SECTION 232123
SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:


1.3 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.

1. Refrigerant piping indicated on Drawings is schematic only. Size piping layout, including oil traps, 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 and in compliance with manufacturer’s requirements.

B. Operation and maintenance data.

1.4 QUALITY ASSURANCE


B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.5 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.
PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR.
B. Wrought-Copper Fittings: ASME B16.22.
C. Wrought-Copper Unions: ASME B16.22.
D. Brazing Filler Metals: AWS A5.8.

2.2 VALVES AND SPECIALTIES

A. Isolation Valves:
   1. Body and Bonnet: Forged brass or cast bronze.
   2. Packing: Molded stem, back seating, and replaceable under pressure.
   3. Operator: ¼ Turn.
   5. Seal Cap: Forged-brass or valox hex cap.
   8. Maximum Operating Temperature: 300 deg F.

2.3 REFRIGERANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Atofina Chemicals, Inc.
   2. DuPont Company.
   3. Honeywell, Inc.
   4. Approved equal.

B. ASHRAE 34, R-410A: Azeotrope.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Suction Hot Gas and Liquid Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install isolation valves in suction, discharge and liquid lines of each terminal unit as specified.

3.3 PIPING INSTALLATION

A. Install refrigerant piping according to ASHRAE 15.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

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

E. Install piping adjacent to machines to allow service and maintenance.

F. Install piping free of sags and bends.

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

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

I. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

J. 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 if valves or equipment requiring maintenance are concealed behind finished surfaces.

K. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

L. 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 to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

M. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

N. Install pipe sleeves at penetrations in interior and exterior walls and floor assemblies as specified in Division 15 Section “Common Work Results for Mechanical”.
O. Seal penetrations through fire and smoke barriers as required by code.

P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

Q. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

R. Seal pipe penetrations through exterior walls as specified in Division 15 Section “Common Work Results for Mechanical”.

S. Identify refrigerant piping and valves as specified in Division 15 Section “Identification for Mechanical Piping and Equipment”.

3.4 PIPE JOINT CONSTRUCTION

A. 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.

3.5 HANGERS AND SUPPORTS

A. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

B. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/4: Maximum span, 60 inches; minimum rod size, 3/8 inch.
2. NPS 3/8: Maximum span, 60 inches; minimum rod size, 3/8 inch.
3. NPS 1/2: Maximum span, 60 inches; minimum rod size, 3/8 inch.
4. NPS 5/8: Maximum span, 60 inches; minimum rod size, 3/8 inch.
5. NPS 3/4: Maximum span, 60 inches; minimum rod size, 3/8 inch.
6. NPS 7/8: Maximum span, 60 inches; minimum rod size, 3/8 inch.
7. NPS 1: Maximum span, 72 inches; minimum rod size, 3/8 inch.
8. NPS 1-1/8: Maximum span, 72 inches; minimum rod size, 3/8 inch.

3.6 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping and specialties. 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. If vacuum holds for 12 hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
   4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
   1. Verify that compressor oil level is correct.
   2. Open compressor suction and discharge valves.
   3. Check open compressor-motor alignment and verify lubrication for motors and bearings.

END OF SECTION 232300
SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Rectangular ducts and fittings.
   2. Round ducts and fittings.
   4. Sealants and gaskets.
   5. Hangers and supports.

1.2 PERFORMANCE REQUIREMENTS

A. 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".

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".

1.3 AIR LEAKAGE TESTING OF THE DUCTWORK SYSTEMS:

A. It is the intent of this section to insure the ductwork installed has minimal air leakage.

B. Air leakage testing shall be accomplished by an AABC certified company. Refer to the Test & Balance specifications.

C. **A duct pre-installation conference shall be held prior to the installation of the ductwork.** Present should be the Owner’s representative, Engineer, Test & Balance Contractor, General Contractor, Mechanical Contractor, Sheet Metal Contractor, and Insulation Contractor. At this meeting, the contractor shall advise all of the duct materials and sealant materials to be used to meet the air leakage allowances.

D. The duct systems which will require testing are as follows:
   1. Supply air duct systems.
   2. Return air duct systems.
   3. Outside air duct systems.
   4. Exhaust air duct systems.

E. Testing shall be based on a 10% blind sampling method. The 10% duct sampling shall be selected by the Engineer. If the first 10% sampling does not meet the requirements set forth in this Section and Section “Testing, Adjusting, and Balancing for HVAC,” the first sampling shall
be corrected and an additional 10% shall be sampled until the system(s) maintain an acceptable leakage rate. All remediation and additional testing shall be paid by the Contractor.

F. Do not insulate the air systems prior to testing.

G. The maximum allowable supply, return, exhaust, and outside air leakage rate is 5.0% of the systems design CFM when the ductwork is pressurized to 1.0” WG. (Therefore, if a supply air system is tested, and the supply air fan rated capacity is 10,000 CFM, the allowable leakage is 500 CFM.)

H. All sheet metal ductwork associated with the systems shall be tested. Flexible ductwork shall not be tested. Cap the main duct prior to the central equipment fan connection. Also cap the branch ducts which serve the diffusers at the location in which flexible duct will be installed. Cap ends with sheet metal caps. Seal caps well to avoid air loss at this location. This air loss, from the caps, is included in the noted leakage rate.

I. The noted allowable leakage rate is the total allowable. It shall include leakage associated with the following:
   1. All ductwork as described in above paragraphs.
   2. Access doors.
   3. Volume dampers.
   4. Fire dampers.
   5. End caps used to seal ducts.

J. If any duct system fails a test, the contractor shall reseal the system. It shall then be retested until the duct system meets the leakage allowance at no additional cost to the Owner.

1.4 SUBMITTALS

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

B. Shop Drawings:
   1. Fittings.
   2. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
PART 2 - PRODUCTS

2.1 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."

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

a. Lindab Inc.
b. McGill AirFlow LLC.

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."

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."

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."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   8. Service: Indoor or outdoor.

C. Flanged Joint Sealant: Comply with ASTM C 920.
   2. Type: S.
   3. Grade: NS.
5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. Round Duct Joint O-Ring Seals:
   1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
   2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
   3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. 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."

C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports:

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.
E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 SEAM AND JOINT SEALING

A. Seal duct seams and joints for duct static-pressure and leakage classes specified in "Performance Requirements" Article, according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements," unless otherwise indicated.

B. Seal Classes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements."

3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

C. Hanger Spacing: 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," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.
E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 CONNECTIONS

A. Make connections to equipment with flexible connectors.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.5 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel:

B. Intermediate Reinforcement:

C. Elbow Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
      a. 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. 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 or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

D. 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: 45-degree entry.

2. Round: 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."

   a. Round main to Round Branch: 45-degree lateral.
   b. Saddle taps and 90 degree conical tees are not permitted.

END OF SECTION 233113
SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   2. Fire dampers.
   3. Turning vanes.
   4. Duct-mounted access doors.
   5. Flexible connectors.
   6. Flexible ducts.
   7. Duct accessory hardware.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Operation and maintenance data.

1.3 QUALITY ASSURANCE

B. Comply with AMCA 500-D testing for damper rating.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653.
   2. Exposed-Surface Finish: Mill phosphatized.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Subject to compliance with requirements, provide products by one of the following:
      a. Arrow United Air.
      b. Greenheck Fan Corporation.
      c. Nailor Industries.
      d. Ruskin Company.
      e. United Enertech.
      f. Approved equal.
   2. Standard leakage rating, with linkage outside airstream.
   3. Suitable for horizontal or vertical applications.
   4. Frames:
      a. Hat-shaped, galvanized-steel channels, 0.064-inch minimum thickness.
      b. Mitered and welded corners.
      c. Flanges for attaching to walls and flangeless frames for installing in ducts.
   5. Blades:
      a. Multiple or single blade.
      b. Opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Galvanized-steel, 0.064 inch thick.
   7. Bearings:
      a. Molded synthetic.
      b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
   8. Tie Bars and Brackets: Galvanized steel.
   9. Standoff with Locking Quadrant: 2 inch minimum.

2.3 FIRE DAMPERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. Arrow United Air.
   2. Greenheck Fan Corporation.
   4. Ruskin Company.
5. United Enertech.
6. Approved equal.

B. Type: “B” dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type “B” with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Minimum Thickness: 0.052 or 0.138 inch thick, as indicated, and of length to suit application.
   2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.


2.4 TURNING VANES

A. Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

C. Vane Construction: Double wall.

2.5 DUCT-MOUNTED ACCESS DOORS

A. Subject to compliance with requirements, provide products by one of the following:
   1. Arrow United Air.
   2. Greenheck Fan Corporation.
   4. Ruskin Company.
   5. United Enertech.
   6. Approved equal.

1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   d. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Piano hinge and two sash locks.

2.6 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Ventfabrics, Inc.
3. Approved equal.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.


   1. Minimum Weight: 26 oz./sq. yd.
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

2.7 FLEXIBLE DUCTS

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

1. Atco.
2. Hart and Cooley.
3. ThermaFlex.
4. Approved equal.
B. Insulated, Flexible Duct: 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 positive and 1.0-inch wg negative.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation Value: R-6.0 minimum.

C. Flexible Duct Connectors:

1. Clamps: Nylon strap in sizes 3 through 8 inches, to suit duct size.

2.8 DUCT ACCESSORY HARDWARE

A. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts.

C. Install volume dampers at points on supply, return, and relief/exhaust systems where branches extend from larger ducts.

1. Install steel volume dampers in steel ducts.

D. Set dampers to fully open position before testing, adjusting, and balancing.

E. Install fire dampers according to UL listing.

F. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. Adjacent to and close enough to fire dampers, to reset or reinstall fusible links.
2. On both sides of duct silencers.
3. Elsewhere as indicated.

G. Install access doors with swing against duct static pressure.

H. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
I. Label access doors.

J. Install flexible connectors to connect ducts to equipment.

K. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

L. Connect diffusers to low-pressure ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

M. Connect flexible ducts to metal ducts with draw bands.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION 233300
SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Ceiling-mounting ventilators.
   2. Centrifugal roof ventilators.
   3. In-line centrifugal ventilators.

1.2 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

B. Operation and maintenance data.

1.3 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. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

C. UL Standard: Power ventilators shall comply with UL 705.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Greenheck.
   2. JencoFan; Div. of Breidert Air Products.
   3. Loren Cook Company.
   4. Approved equal.

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. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Direct Drive Assembly: Resiliently mounted to housing, with the following features:
   1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

F. Accessories, as specified on drawings:
   1. Bird Screens: Removable, 1/2-inch mesh, aluminum wire.
   2. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
   2. Overall Height: As specified on drawings.
   5. Burglar Bars: 5/8-inch-thick steel bars welded in place to form 6-inch squares.

2.2 CEILING-MOUNTING VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Greenheck.
   2. JencoFan; Div. of Breidert Air Products.
   3. Loren Cook Company.
   4. Approved equal.

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. Isolation: Rubber-in-shear vibration isolators.
2. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.3 IN-LINE CENTRIFUGAL FANS

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

1. Aerovent.
2. Greenheck.
3. Loren Cook Company.
4. Penn Barry.
5. Approved equal.

B. Description: In-line, direct-driven centrifugal fans consisting of housing, wheel, 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 out of airstream, factory wired to disconnect switch located on outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:

1. Companion Flanges: For inlet and outlet duct connections.
3. As specified on drawings.

2.4 MOTORS

A. Enclosure Type: Totally enclosed, fan cooled.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using elastomeric mounts having a static deflection of 1 inch.
C. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

D. Support suspended units from structure using threaded steel rods and elastomeric hangers having a static deflection of 1 inch.

E. Install units with clearances for service and maintenance.

F. Label units according to requirements.

G. Duct installation and connection requirements are specified in other Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.

H. Install ducts adjacent to power ventilators to allow service and maintenance.

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

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

END OF SECTION 233423
SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Single-duct air terminal units.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. Operation and maintenance data.

1.3 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. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

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. Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SINGLE-DUCT AIR TERMINAL UNITS – PRESSURE INDEPENDENT

A. Manufacturers:

1. Trane.
2. Nailor Industries of Texas Inc.
3. Titus.
4. Approved equal.
B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

C. Casing: 0.034-inch steel.
   2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections.
   4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.

D. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
   1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
   2. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.

F. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

C. Install piping adjacent to air terminal units to allow service and maintenance.

D. Hot-Water Piping: In addition to requirements in Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

E. Connect ducts to air terminal units according to Section "Metal Ducts."
3.2 FIELD QUALITY CONTROL

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

1. After installing air terminal units, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 233600
SECTION 233713 - DIFFUSERS AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Diffusers and grilles.

1.2 SUBMITTALS

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

B. Samples: For each color specified.

PART 2 - PRODUCTS

2.1 DIFFUSERS AND GRILLES

A. Diffusers and Grilles, as specified on drawings:
   1. Subject to compliance with requirements, provide products by one of the following:
      a. Krueger.
      b. Nailor Industries.
      c. Price Industries.
      d. Titus.
      e. Approved equal.

2.2 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install diffusers and grilles level and plumb.

B. Ceiling- and Wall-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where Architectural features or other items conflict with installation, notify Engineer for a determination of final location.

C. Install diffusers and grilles with airtight connections to ducts and to allow service and maintenance of volume and fire dampers.

3.2 ADJUSTING

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

END OF SECTION 233713
SECTION 233716 - LOUVERS AND VENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fixed, extruded-aluminum and formed-metal louvers.
2. Wall vents (brick vents).

1.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Louvers shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver blade rattle or flutter, or permanent damage to fasteners and anchors.

   1. Wind Loads: Determine loads based on a uniform pressure of 30 lb/sq. ft., acting inward or outward.

B. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.

C. Louver shall be UL Listed and comply with FEMA 320, FEMA 360, and ICC 500.

1.3 SUBMITTALS

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

   1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections and details. Show frame profiles and blade profiles, angles, and spacing.

C. Samples: For each type of metal finish required.

D. Product Test Reports: Based on tests performed according to AMCA 500-L.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Extrusions:  ASTM B 221, Alloy 6063-T5, T-52, or T6.

B. Aluminum Sheet:  ASTM B 209, Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet:  ASTM A 653/A 653M, G90 zinc coating, mill phosphatized.

D. Stainless-Steel Sheet:  ASTM A 240/A 240M, Type 304, No. 4 finish.

E. Fasteners: Use types and sizes to suit unit installation conditions.
   1. For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.
   2. For fastening galvanized steel, use hot-dip-galvanized steel or 300 series stainless-steel fasteners.
   3. For fastening stainless steel, use 300 series stainless-steel fasteners.
   4. For color-finished louvers, use fasteners with heads that match color of louvers.

2.2 FABRICATION, GENERAL

A. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

B. Join frame members to each other and to fixed louver blades with fillet welds, threaded fasteners, or both, as standard with louver manufacturer unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.3 FIXED, FORMED-METAL LOUVERS

A. Louver:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Air Balance Inc.
      b. Greenheck Fan Corporation.
      c. Ruskin Company.
      d. Approved equal.
   2. Louver Depth: As specified on drawings.
   3. Frame and Blade Material and Nominal Thickness: Stainless-steel sheet, not less than 0.25 inch.
   4. Louver Performance Ratings: As specified on drawings
   5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
6. Louver shall be UL Listed.
7. Louver shall comply with: FEMA 320, FEMA 361, and ICC 500.

2.4 LOUVER SCREENS

A. General: Provide screen at each exterior louver.

B. Louver Screen Frames: Same kind and form of metal as indicated for louver to which screens are attached.

C. Louver Screening:
   1. Bird Screening: Aluminum, 1/2-inch-square mesh, 0.063-inch wire.

2.5 WALL VENTS (BRICK VENTS)

A. Extruded-Aluminum Wall Vents:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Greenheck Fan Corporation.
      b. Ruskin Company; Tomkins PLC.
      c. Approved equal.

   2. Extruded-aluminum louvers and frames, not less than 0.125-inch nominal thickness, assembled by welding; with 18-by-14- mesh, aluminum insect screening on inside face; incorporating weep holes, continuous drip at sill, and integral waterstop on inside edge of sill; of load-bearing design and construction.

B. Cast-Aluminum Wall Vents:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Greenheck Fan Corporation.
      b. Ruskin Company; Tomkins PLC.
      c. Approved equal.

   2. One-piece, cast-aluminum louvers and frames; with 18-by-14- mesh, aluminum insect screening on inside face; incorporating integral waterstop on inside edge of sill; of load-bearing design and construction.

2.6 ALUMINUM FINISHES

A. High-Performance Organic Finish: 3-coat fluoropolymer finish complying with AAMA 2604 and containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
1. Color and Gloss: As selected by Architect from manufacturer's full range.

2.7 GALVANIZED-STEEL SHEET FINISHES

A. Finish louvers after assembly.

B. Surface Preparation: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas and repair according to ASTM A 780.

C. Baked-Enamel or Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard 2-coat, baked-on finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat. Comply with coating manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils.

1. Color and Gloss: As selected by Architect from manufacturer's full range.

2.8 STAINLESS-STEEL SHEET FINISHES

A. Repair sheet finish by grinding and polishing irregularities, weld spatter, scratches, and forming marks to match surrounding finish.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate and place louvers and vents level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

D. Repair damaged finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory and refinish entire unit or provide new units.

E. Protect galvanized and nonferrous-metal surfaces that will be in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint.

END OF SECTION 233716
SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.


C. Source quality-control test reports.

D. Field quality-control test reports.

E. Operation and maintenance data.

F. Warranty: Special warranty specified in this Section.

1.3 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. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

   1. Warranty Period for Condensing Boilers shall be as specified on drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 MANUFACTURED UNITS – CONDENSING BOILER

A. Description: Factory-fabricated, -assembled, and -tested, condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.

   1. Manufacturers:

      a. Lochinvar, Knight XL.
      b. Fulton
      c. Aerco.
      d. Approved equal.

   B. Characteristics and Capacities as specified on drawings.

2.3 TRIM

A. Include devices sized to comply with ANSI B31.9, "Building Services Piping."

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch- diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic.

2.4 ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color-coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface shall be to nonfused disconnect switch.
5. Provide branch power circuit to each motor and to controls with a disconnect switch.
6. Provide each motor with overcurrent protection.

2.5 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 BOILER INSTALLATION

A. Install boilers level on concrete base.

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory-mounted.

E. Install control wiring to field-mounted electrical devices.

3.2 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service.

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Boiler Venting:
   1. Install flue venting kit and combustion-air intake.
   2. Connect full size to boiler connections.

3.3 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 components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Perform installation and startup checks according to manufacturer's written instructions.
   2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
   3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
      a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
      b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

3.4 DEMONSTRATION

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

END OF SECTION 235216
SECTION 235533 - FUEL-FIRED UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes gas-fired unit heaters.

1.2 SUBMITTALS
   A. Product Data: For each type of fuel-fired unit heater indicated. Include rated capacities, operating characteristics, and accessories.
   B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   C. Field quality-control test reports.
   D. Operation and maintenance data.

1.3 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.

1.4 WARRANTY
   A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace heat exchanger of fuel-fired unit heater that fails in materials or workmanship within specified warranty period.
      1. Heat Exchanger Warranty Period: Ten years from date of Substantial Completion.
      2. Parts Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GAS-FIRED UNIT HEATERS
   A. Subject to compliance with requirements, provide products by one of the following:
1. Greenheck.
4. Sterling HVAC Products; Div. of Mestek Technology Inc.
5. Approved equal.

B. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.

C. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.

D. Type of Venting: Indoor, separated combustion, power vented.

E. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.


G. Burner Material: Stainless steel.

H. Unit Fan: Propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.

I. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

1. Gas Control Valve: Single stage.
2. Ignition: Electronically controlled electric spark with flame sensor.
3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
5. Control transformer.
6. High Limit: Thermal switch or fuse to stop burner.
7. Thermostats: Devices and wiring are specified in Division 23 Section "Instrumentation and Control for HVAC."
8. Thermostat: Single-stage, wall-mounting type with 50 to 90 deg F operating range and fan on switch.

J. Discharge Louvers: Independently adjustable horizontal blades.

K. Accessories:

1. Vertical discharge louvers.
2. Discharge Nozzle: Discharge at 50 to 90 degrees from horizontal.
3. Four-point suspension kit.
4. Summer fan switch.
5. Unit-mounted thermostat bracket.
6. Power Venter: Centrifugal aluminized-steel fan, with stainless-steel shaft; 120-V ac motor.
7. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.
L. Capacities and Characteristics:

1. As specified on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and connect gas-fired unit heaters and associated fuel and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written installation instructions.

B. Install and connect oil-fired unit heaters and associated fuel and vent piping according to NFPA 31, applicable local codes and regulations, and manufacturer's written installation instructions.

C. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

D. Install piping adjacent to fuel-fired unit heater to allow service and maintenance.

E. Gas Piping: Comply with Section "Facility Natural-Gas Piping." Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.

F. Adjust initial temperature set points.

G. Adjust burner and other unit components for optimum heating performance and efficiency.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 235533
SECTION 237333 - PACKAGED, OUTDOOR, HEATING ONLY MAKEUP AIR-UNIT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes a heating only makeup air unit.

1.2 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Include details of installation and wiring diagrams.

C. Coordination Drawings: Rooftop makeup-air units to roof-curb mounting 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. Size and location of rooftop makeup-air unit mounting rails and anchor points and methods for anchoring units to roof curb.
2. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.

D. Startup service reports.

E. Operation and maintenance data.

F. Warranty.

1.3 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of rooftop make up air units and are based on the specific system indicated.

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

1.4 COORDINATION

A. Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 15 Section “Common Work Results for Mechanical”.

B. Coordinate size, location, and installation of rooftop make up air unit manufacturer's roof curbs and equipment supports with roof Installer.

1. Coordinate installation of restrained vibration isolation roof-curb rails, which are specified in Division 15 Section “Vibration and Seismic Controls for Mechanical Piping and Equipment”.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than ten (10) years from date of Substantial Completion.

1.6 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 Belts: One set for each belt-driven fan.
2. Filters: One set for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Greenheck.
2. Modine.
3. Reznor.
4. Approved equal.

2.2 CABINET

A. Construction: Double wall.

B. Exterior Casing: Galvanized steel with baked-enamel paint finish and with lifting lugs and knockouts for electrical and piping connections.
C. Interior Casing: Galvanized steel.

D. Base Rails: Galvanized-steel rails for mounting on roof curb.

E. Service Doors: Hinged access doors with neoprene gaskets.

F. Internal Insulation: Fibrous-glass duct lining complying with ASTM C 1071, Type II.
   1. Thickness: 1 inch.
   2. Insulation Adhesive: Comply with ASTM C 916, Type I.
   3. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical
      attachment, or welding attachment to casing without damaging liner and without causing
      air leakage when applied as recommended by manufacturer.

G. Roof Curb: Full-perimeter curb of sheet metal, minimum sixteen (16) inches high, with wood
   nailer, neoprene sealing strip, and welded Z-bar flashing.

2.3 SUPPLY-AIR FAN

A. Fan: Forward-curved centrifugal; statically and dynamically balanced, galvanized steel,
   mounted on solid-steel shaft with self-aligning, permanently lubricated ball bearings.

B. Motor: As specified on drawings.

C. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly
   with minimum 1.4 service factor.

D. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with spring isolators.

2.4 INDIRECT-FIRED GAS FURNACE

A. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel
   1. AGA Approval: Designed and certified by and bearing label of AGA.

B. Burners: Stainless steel with a minimum thermal efficiency of 80 percent.
   1. Fuel: Natural gas.
   2. Ignition: Electronically controlled electric spark with flame sensor.

C. Heat-Exchanger Drain Pan: Stainless steel.

D. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.

E. Safety Controls:
   1. Gas Control Valve: Electronic modulating.

2.5 OUTDOOR-AIR INTAKE AND DAMPERS

A. Dampers: Leakage rate, according to AMCA 500, shall not exceed 2 percent of air quantity at face velocity of 2000 fpm through damper and pressure differential of 4-inch wg.

B. Damper Operators: Electric.

C. Mixing Boxes: Parallel-blade, galvanized-steel dampers mechanically fastened to steel operating rod inside cabinet. Connect operating rods with common interconnecting linkages so dampers operate simultaneously.

D. Outdoor-Air Intake Hoods: Galvanized steel, with bird screen and finish to match cabinet.

2.6 FILTERS

A. Comply with NFPA 90A.

B. Cleanable Filters: 2-inch-thick, cleanable metal mesh.

2.7 CONTROLS

A. Factory-wire connection for controls' power supply.

B. Control devices, including sensors, transmitters, relays, switches, thermostats, detectors, operators, actuators, and valves, shall be manufacturer's standard items to accomplish indicated control functions.

C. Unit Controls: Solid-state control board and components with field-adjustable control parameters.

D. Supply-Fan Control: Units shall be electrically interlocked with corresponding exhaust fans, to operate continuously when exhaust fans are running.

E. Heating Controls:

1. Factory-mounted sensor in supply-fan outlet with sensor adjustment located in control panel modulates gas furnace burner to maintain space temperature.

F. Damper Controls: When exhaust fans stop, set outdoor-air damper to 0 percent. When exhaust fans start, fully open outdoor-air damper.
3.1 INSTALLATION

A. Install roof curb on roof structure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure rooftop make-up-air unit on curb and coordinate roof penetrations and flashing with roof construction.

B. Install duct-mounting sensors and thermostats furnished by manufacturers for field installation. Install control wiring and make final connections to control devices and unit control panel.

C. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

D. Install piping adjacent to machine to allow service and maintenance.
   1. Gas Burner Connections: Comply with requirements in Division 15 Section “Facility Natural-Gas Piping”. Connect gas piping to burner, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.

E. Duct Connections: Duct installation requirements are specified in Division 15 Section “Metal Ducts”. Drawings indicate the general arrangement of ducts. Connect supply and return ducts to rooftop replacement-air units with flexible duct connectors. Flexible duct connectors are specified in Division 15 Section “Air Duct Accessories”.

F. Electrical Connections: Comply with requirements in other Specification Sections for power wiring, switches, and motor controls.

G. Ground equipment according to other Specification Sections.

3.2 STARTUP SERVICE

A. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   1. Inspect for visible damage to furnace combustion chamber.
   2. Inspect for visible damage to supply and fan.
   3. Inspect casing insulation for integrity, moisture content, and adhesion.
   4. Verify that controls are connected and operable.
   5. Clean furnace flue and inspect for construction debris.
   6. Inspect operation of power vents.
   7. Purge gas line.
   8. Verify bearing lubrication.
   9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
  10. Adjust fan belts to proper alignment and tension.
  11. Start unit.
12. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.

13. Operate unit for run-in period.

14. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
    a. Measure gas pressure at manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure flue-gas temperature at furnace discharge.
    e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

15. Calibrate thermostat.


17. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.

18. Verify operational sequence of controls.

19. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
    a. High-limit heat exchanger.
    b. Alarms.

B. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace components that do not pass tests and inspections and retest as specified above.

D. Prepare written report of the results of startup services.

3.3 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain make up-air unit. Refer to Division 15 Section “General Provisions for Mechanical”.

END OF SECTION 15733
SECTION 237413 - PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes packaged, outdoor, variable-volume air-handling units with the following components and accessories:

1. Direct-expansion cooling.
2. Gas furnace.
3. Economizer outdoor- and return-air damper section.

1.2 DEFINITIONS

A. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

B. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

C. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units.

D. Supply-Air Fan: The fan providing supply-air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

E. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

F. VAV: Variable-air volume.

1.3 PERFORMANCE REQUIREMENTS

A. As specified on drawings.

1.4 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.


C. Field quality-control test reports.

D. Operation and maintenance data.

E. Warranty.

1.5 QUALITY ASSURANCE

A. ARI Compliance:

1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with ARI 270 for testing and rating sound performance for RTUs.

B. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigerant system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with ASHRAE/IESNA 90.1 for minimum efficiency of heating and cooling.

C. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.


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

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than ten (10) years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than one (1) year from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than one (1) year from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. AAON, Inc.
   2. Carrier Corporation.
   3. Trane.
   4. Approved equal.

2.2 CASING

A. General Fabrication Requirements for Casings: Formed and reinforced insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

C. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
   1. Materials: ASTM C 1071, Type I.
   2. Thickness: 1 inch.
   3. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
   4. Liner Adhesive: Comply with ASTM C 916, Type I.

D. Condensate Drain Pans: Formed sections of stainless-steel sheet, a minimum of 2 inches deep, and complying with ASHRAE 62.
   1. Drain Connections: Threaded nipple.

2.3 FANS

A. Supply-Air Fans: Double width, centrifugal; with permanently lubricated, motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

B. Exhaust-Air Fans: Double width, centrifugal; with permanently lubricated, motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

C. Provide supply and exhaust fans with variable frequency drive.

2.4 COILS

A. Supply-Air Refrigerant Coil:
1. Aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
4. Condensate Drain Pan: Stainless steel formed or polymer with pitch and drain connections complying with ASHRAE 62.

B. Outdoor-Air Refrigerant Coil:

1. Aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.

2.5 REFRIGERANT CIRCUIT COMPONENTS

A. Compressor: Scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

B. Refrigeration Specialties:

1. Refrigerant Charge: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
5. Automatic-reset low-pressure safety switch.
8. Brass service valves installed in compressor suction and liquid lines.

2.6 AIR FILTRATION

A. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. As specified on drawings.

2.7 GAS FURNACE

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54.

1. CSA Approval: Designed and certified by and bearing label of CSA.

B. Burners: Stainless steel with a minimum thermal efficiency of 80 percent.

1. Fuel: Natural gas.
2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.

C. Heat-Exchanger and Drain Pan: Stainless steel or polymer.

D. Venting: Gravity vented.

E. Safety Controls:

1. Gas Control Valve: Modulating.

2.8 DAMPERS

A. Outdoor-Air Damper: Linked damper blades, for 0 to 100 percent outdoor air, with motorized damper actuator.

B. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.

1. Damper Motor: Modulating with adjustable minimum position.
2. Relief-Air Damper: Gravity actuated with bird screen and hood incorporated in power exhauster.

2.9 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.10 CONTROLS

A. Control equipment and sequence of operation are specified in Division 23 Section "Instrumentation and Control for HVAC."

2.11 ACCESSORIES

A. As specified on drawings.

2.12 VIBRATION ISOLATION ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Manufacturers
1. Subject to compliance with requirements, provide products by the following:
   a. Mason Industries.
   b. Kinetics.
   c. Approved equal.

C. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
   1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
      a. Materials: ASTM C 1071, Type I or II.
      b. Thickness: 2 inches.
   2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
      a. Liner Adhesive: Comply with ASTM C 916, Type I.
      b. 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 cabinet.
      c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
      d. Liner Adhesive: Comply with ASTM C 916, Type I.

D. Curb Height: 16 inches.

E. Wind and Seismic Restraints: Comply with requirements in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for wind-load requirements. See drawings for curb requirements.

F. RTU’s shall withstand the effects of an earth-quake determined by SEI/AS CE7.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to ARI Guideline B. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07 Section "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure roof curb to structural support with anchor bolts.

C. Install condensate drain, minimum connection size, with trap and indirect connection to nearest gutter.
D. Install piping adjacent to RTUs to allow service and maintenance.

   1. Gas Piping: Comply with applicable requirements in Division 23 Section "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

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. Report results in writing.

B. Tests and Inspections:

   1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.3 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

END OF SECTION 237413
SECTION 238100 - VRV EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes variable refrigerant volume heat recovery units (three-pipe) with the following components and accessories:

1. Outdoor Condensing Units.
2. Indoor Terminal Units.
3. Electrical Connections.
4. System Controls.
5. Outdoor Unit Equipment Stands.

1.2 PERFORMANCE REQUIREMENTS

A. Basic Equipment Performance:

1. The VRV Heat Recovery systems shall be installed to provide heating and cooling simultaneously to the areas via individually controlled terminal units on the same refrigeration circuit.
2. The outdoor equipment shall be an Air Cooled Modular Design Variable Refrigerant Volume (VRV) system.
3. The VRV system shall be an Inverter Driven Heat Recovery system, which operates on R-410A refrigerant. Heat Recovery is achieved by diverting exhaust heat from indoor units in cooling to areas requiring heating. See equipment schedules for details of equipment selected.
4. Each system shall be based on one modular outdoor air cooled condensing unit connected via a single refrigerant circuit comprising suction, discharge and liquid pipe work for indoor terminal units, of different types and capacities. The total load of which should not exceed the total outdoor unit’s capability index (refer to Manufacturer for capability index combinations).
5. The systems shall be capable of operating when ambient temperatures vary between 109.4° F db and 23° F db in both cooling mode and in Heat Recovery mode, and between -4° F db and 59.9° F db in heating mode. The internal temperature control range is between 60.8° F db and 89.6° F db.
6. The refrigerant pipe work circuit shall be capable of being extended up to 330 feet actual (410 ft. equivalent) length between the outdoor condensing unit and the furthest indoor unit on the circuit and may incorporate a maximum of 165 feet of level difference without the necessity for any oil traps. The level difference between indoor units on one system shall be capable of being extended to up to 50 feet.
7. Operation of the system shall permit either individual cooling or heating of each terminal unit simultaneously. Each terminal unit shall be able to provide set temperature independently via a local zone controller and/or input from facility HVAC controls system.
1.3 SUBMITTALS

A. **Base and Alternate Bid Equipment Suppliers:** Shall furnish to the Mechanical Contractor a complete engineering equipment manual in printed or electronic form (PDF). The Manual shall cover in detail all requirements for electrical, equipment installation, refrigerant piping, equipment capacities and controls installation.

B. **Alternate Equipment Suppliers:** Shall in addition to the base requirements above, provide to the Bidding Mechanical Contractor two (2) complete Equipment Data Packages. These packages shall include, but are not limited to, equipment capacities, power requirements, indoor units CFM/static pressures, EER/COP, installation requirements, and physical dimensions. The Equipment Manufacturer shall provide with the Equipment Data Packages two (2) drawing package sets as referenced below, plotted on 20 lb. bond to the Mechanical Contractor prior to bid for review and inclusion with the Equipment Data Package required to be presented at time of bid.

1. The Mechanical Contractor shall list alternate equipment supplier and submit one (1) copy of the required Data Package with his Bid for review by the Engineer.

2. The Alternate Equipment Supplier shall furnish to the Mechanical Contractor for installation a complete Drawing Package. The drawing format shall be ACAD 2000 or higher, on 30"x42" sheets. The HVAC and Electrical series design documents will be made available in electronic format for use by the Equipment Supplier in preparing their drawings. The Alternate Equipment Supplier shall draft all piping circuits, components, overall building control schematic, detailed control wiring diagrams, system details and schedules for their system. The drawings shall convey all requirements to successfully install the Equipment Supplier’s System. Every sheet will include the submitted VRV equipment manufacturer’s logo in the title block with drawn/approved by information included. The issue date on the drawings will not change.

C. The submitted documents shall be the complete system design and show no less information than the HVAC Equipment/Controls Contract Bid Documents.

D. **Product Data:** Include manufacturer's technical data for each piece of equipment, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

E. **Shop Drawings:**

1. **Wiring Diagrams:** Power, signal, and control wiring.

2. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Provide (8) drawing package sets plotted on 20 lb. bond and (1) drawing design package in electronic format (ACAD files) on CD to the engineer with completed shop drawings for review as per Specification Section 230000.

F. **Field quality-control test reports as specified.**

G. **Operation and maintenance data.**

H. **Warranties.**
1.4 QUALITY ASSURANCE

A. ETL Compliance: Units shall be listed by Electrical Laboratories (ETL) and bear the ETL label.

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

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of the VRV system that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than six (6) years from date of Substantial Completion.
2. Warranty Period for Parts: Manufacturer's standard, but not less than one (1) year from date of Substantial Completion.
3. Warranty Period for Labor: Manufacturer's standard, but not less than one (1) year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Carrier.
2. Daikin Industries
3. Mitsubishi.
4. Panasonic.
5. Approved equal.

2.2 OUTDOOR UNITS

A. Outdoor Units: Heat Recovery type, selected from manufacturer’s model range to suit the required capacity. See equipment schedules for details of equipment selected. The outdoor condensing units shall be completely weather-proofed to be corrosion resistant. Unit shall be factory assembled in a sturdy weatherproofed casing constructed from rust-proofed mild steel panels with an oven-baked enamel finish. Unit shall be pre-charged, pre-wired and completed with all necessary electronic and refrigerant controls for ease of installation and factory tested.

1. Heat Exchanger: The heat exchanger on the condensing units shall be manufactured from seamless copper tube mechanically bonded to aluminum fins. The fins are to be covered
with an anti-corrosion Acrylic resin. The pipe plates shall be treated with powdered polyester resin for corrosion prevention.

2. Compressor: The compressor(s) shall be of the high-efficiency inverter-duty Scroll type. Each outdoor unit shall be fitted with inverter driven compressor(s), electronically controlled and capable of changing the speed linearly to follow the variations in cooling or heating load. In the cases of two or more compressors, there shall be duty balancing. Capacity control of the outdoor unit shall be inverter controlled with a by-pass for minimum capacity control of 10%. The frequency of inverter control shall be determined electronically by sensing ambient temperatures, operational pressures and monitoring the exact requirement of all of the connected indoor units. The outdoor unit shall be capable of working with one ON/OFF compressor for eight (8) hours in the case of inverter compressor failure.

3. Electronics: The outdoor electronics shall have selection switches for the length of pipe work, ambient range selection, emergency operation switches, and service mode switches, together with LED indications for the number of fan coils connected, the frequency status and operational/fault indication. The control circuit shall have a pump down facility to enable collection of the entire refrigerant charge in the system at the outdoor unit. The units shall have microprocessor control system incorporated to enable oil return, stability of refrigerant flow and capacity balancing.

4. Safety devices:
   a. High and low pressure switches.
   b. Control circuit fuses.
   c. Crank case heaters.
   d. Thermal protectors for compressor and fan motors.
   e. Over current protection for inverter.
   f. Anti-short cycling timers.

5. Refrigeration circuit: Shall include a Bridge Circuit complete with solenoid valves, 4 way valve(s), distribution headers, capillaries, filters, shut off valves, service ports and receivers.

6. Oil recovery cycle: shall be automatic, occurring one (1) hour after start of operation and then every eight (8) hours of operation. Oil separators are standard with the equipment together with oil equalization system between compressors and condensers.

7. Outdoor condensing fan: Impeller shall be designed for low noise operation. The fan motor shall be inverter-duty with speed control to maintain constant head pressure control in all ambient conditions and modes of operation.

8. Night set back control of the fan motor for low noise operation by way of limiting the maximum speed will be permitted.

9. The condensing units shall be capable of sequential start when more than one unit is installed and have an auto restart capability after power failure as standard.

2.3 INDOOR UNITS

A. Indoor Terminal Units: shall consist of a fan, heat exchanger, and an electronic proportional expansion valve which shall be controlled via computerized PID control which measures and assesses the status of the return air temperature and refrigerant inlet and outlet temperature. The indoor units shall be selected as specified on the equipment schedules. During the cooling operation the electronic expansion valve shall control the degree of refrigerant superheat at the
evaporator outlet. During the heating operation it shall control the degree of refrigerant subcooling at the condenser outlet.

1. Circuit board: Shall be complete with power input fusing, operation controls, emergency operation switch, and fault/operation indication LED's.
2. Fan motors: shall be thermally protected.
3. Unit casings: shall be fully insulated and sealed to prevent condensation.
4. Condensate Drain Pans: Formed sections, a minimum of 2 inches deep, and complying with ASHRAE 62.

2.4 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to outdoor and indoor units respectively with non-fused unit-mounted disconnect switch accessible from outside the unit.

2.5 CONTROLS

A. Basic Unit Controls:

1. Control-voltage transformer.
2. Wall-mounted digital thermostat or DDC controller with the following features:
   b. Fan on-auto switch.
   c. Fan-speed switch.
   d. Automatic changeover.
   e. Adjustable deadband.
   f. Exposed set point.
   g. Exposed indication.
   h. Degree F indication.
   i. Unoccupied-period-override push button.
   j. Data entry and access port to input temperature set points, occupied and unoccupied periods, and output room temperature, supply-air temperature, operating mode, and status.

3. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of two programmable periods per day.
4. Unoccupied Period:
   a. Heating Setback: 10° F.
   b. Cooling Setback: 7° F.
   c. Override Operation: Two hours.

5. Supply Fan Operation:
   a. Occupied Periods: Run fan continuously.
   b. Unoccupied Periods: Cycle fan to maintain setback temperature.

6. Refrigerant Circuit Operation:
a. Occupied Periods: Cycle compressors to match compressor output to cooling load to maintain room temperature.
b. Unoccupied Periods: Compressors off.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Outdoor Equipment Mounting: Install outdoor units on concrete base using elastomeric mounts. Comply with requirements for concrete base as specified.


B. Suspend above-ceiling terminal units from structure with threaded steel rods and minimum 1.0-inch static deflection rubber-in-shear vibration isolators.

C. Install wall-mounting equipment controls in electrical outlet boxes at heights to match lighting controls or as specified.

D. Drawings indicate general arrangement of refrigerant piping, fittings, and specialties. Specific connection requirements are as follows:

   1. Connect refrigerant piping to terminal units as specified by equipment manufacturer.
   2. Connect condensate drain pan to indirect waste connection with condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

E. Duct installation requirements are specified in other sections. Drawings indicate general arrangement of ducts. Specific connection requirements are as follows:

   1. Connect supply and return ducts to terminal units with flexible duct connectors.

F. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

G. Install refrigerant piping adjacent to machine to allow service and maintenance.

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. Report results in writing.

B. Tests and Inspections:

   1. After installing terminal units, and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Complete and record pressure test (Holding Pressure).
6. Confirm Record Drawings to assure system is installed per manufacturer’s requirements.
7. Record pipe lengths and diameters and report any deficiencies.
8. Record total refrigerant volumes and report any deficiencies.
9. Perform cooling start-up check and report any deficiencies.
10. Perform heating start-up check and report any deficiencies.
11. Complete and issue Documents and Certificates to Engineer.

C. Should it deemed necessary, full access should be afforded to the site during the installation of the VRV System to allow the Manufacturer’s authorized representative and/or Engineer to verify that the installation methods being used comply with, and are fully in accordance with the VRV System Installation Instructions. This requirement is in place in order to eliminate the possibility that the equipment warranties be invalidated.

D. Remove and replace malfunctioning units and retest as specified above.

3.3 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing of the VRV air-distribution systems, clean filter housings and install new filters.

END OF SECTION 238100
SECTION 238123 - COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Floor mounted computer-room air conditioner.

1.2 SUBMITTALS

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

B. Shop Drawings: For computer-room air conditioners. 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. Color Samples: For unit cabinet and discharge grille, and for each color and texture specified.

D. Field quality-control reports.

E. Operation and maintenance data.

1.3 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 Recommended Best Practice: Conform with current recommended best practice as set forth by ASHRAE Technical Committee 9.9.

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion.
2. Warranty Period for Control Boards: Manufacturer's standard, but not less than one (1) year from date of Substantial Completion.
3. Warranty Period for Parts and Limited Labor: Manufacturer’s standard, but not less than one (1) year from Date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FLOOR MOUNTED UNIT

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

1. Canatal.
2. Data Aire.
3. Liebert Corporation.
4. Stulz.
5. Approved equal.

B. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls.

C. Cabinet: Galvanized steel with baked-enamel finish, insulated with 1/2-inch-thick duct liner.

1. Integral factory-supplied supply and return grille to fit ceiling grid kit of 24 by 48 inches, with filter.
2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

D. Supply-Air Fan: Forward curved, centrifugal, and directly driven by two-speed motor.

E. Refrigeration System as specified on drawings.

F. Filter: 2-inch-thick, 20”Wx20”T disposable, glass-fiber media.

1. Arrestance (ASHRAE 52.1): 60 percent.

G. Disconnect Switch: Unit-mounted, non-fused, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
H. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature-control modules, and time-delay relay.

2.2 FAN MOTORS
A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors as specified.

1. Motor Sizes: Minimum size as indicated.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in other Sections.

2.3 CAPACITIES AND CHARACTERISTICS
A. As specified on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to ARI Guideline B.

3.2 CONNECTIONS
A. Piping installation requirements are specified in Sections "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to machine to allow service and maintenance.
C. Water and Drainage Connections: Comply with applicable requirements in Sections "Hydronic Piping" and "Domestic Water Piping".

3.3 FIELD QUALITY CONTROL
A. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
B. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

D. After startup service and performance test, change filters.

3.4 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 238123
SECTION 260000 - GENERAL PROVISIONS FOR ELECTRICAL

PART 1 – GENERAL

1.1 SCOPE
A. Special Conditions section and General Requirements section are made part of this Division.
B. This Division includes the sections, but not necessarily limited to, listed in the Division Table of Contents.

1.2 GENERAL
A. The work included in this division consists of furnishing all labor, equipment, transportation, excavation, backfill, supplies, material, appurtenances and services necessary for the satisfactory installation of the complete and operating Electrical System(s) indicated or specified in the Contract Documents.
B. Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete or perfect any part of the Electrical Systems in a substantial manner, in compliance with the requirements stated, implied or intended in the drawings and/or specifications, shall be included as part of this Contract.
C. It is the intent of this Contract to deliver to the Owner’s a “like new” project once work is complete. Although plans and specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing items which interfere with the new work required for the complete installation without additional cost to the Owner.

1.3 INTENT
A. It is the intention of the Contract Documents to call for finished work, tested and ready for operation.
B. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

1.4 EXAMINATION OF SITE AND CONDITIONS
A. Each Proposer shall inform himself of all conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work. Each Proposer shall also fully acquaint himself with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of utilities, etc. His proposal shall cover all
expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after bids are accepted.

1.5 DRAWINGS AND SPECIFICATIONS

A. The drawings are diagrammatic only and indicate the general arrangement of the work to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The drawings are not intended to show every item, which may be necessary to complete the systems. All Proposers shall anticipate that additional items may be required and submit their bid accordingly.

B. The drawings and specifications are intended to supplement each other. No Proposer shall take advantage of conflict between them, or between parties of either. Should this condition exist, the Proposer shall request a clarification not less than twelve days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.

C. The drawings and specifications shall be considered to be cooperative and anything appearing in the specifications, which may not be indicated on the drawings or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.

D. The Contractor shall make all his own measurements in the field and shall be responsible for correct fitting. He shall coordinate this work with all other branches of work in such a manner as to cause a minimum of conflict or delay.

E. The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.

F. Should conflict or overlap (duplication) of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume that he is to be relieved of the work which is specified under his branch until instructions in writing are received from the Engineer.

G. Unless dimensioned, the drawings only indicate approximate locations. Dimensions given in figures on the drawings shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to insure no conflict with other work.

H. Where on the Drawings a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.

I. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.
J. Where on the Contract Documents the word typical is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.

K. Special Note: Always check ceiling heights indicated on Architectural Drawings and Schedules and insure that they may be maintained after all mechanical and electrical equipment is installed. Do not install equipment in the affected area until the conflict is resolved.

1.6 REVIEW OF CONTRACT DOCUMENTS AND FIELD CONDITIONS BY CONTRACTOR

A. By execution of this Contract, the Contractor warrants that he has visited the site of the proposed work, and fully acquainted himself with the conditions there existing relating to construction and labor and that he fully understands the facilities, difficulties, and restrictions attending the execution of the work under Contract. The Contractor further warrants that he has thoroughly examined and is familiar with the drawings, specifications and all other documents comprising the Contract. The Contractor further warrants that by execution of this Contract, his failure, when he was bidding on this Contract, to receive or examine any form, instrument, or document, or to visit the site and acquaint himself with the conditions there existing, in no way relieves the Contractor. The Contractor agrees that the Owner shall be justified in rejecting any claim based on facts regarding conditions for which he should have been on prior notice.

B. Before ordering material or performing any work, the Contractor shall verify all measurements at the work site. Any difference between dimensions on the Drawings and actual measurements shall be brought to the Engineer’s attention for his consideration before the work may proceed. No extra compensation will be allowed because of difference between actual measurements and dimensions indicated on the Drawings. The Contractor shall assume full responsibility for accuracy of measurements obtained at the Work Site.

C. Dimensions, which are lacking, shall be obtained from the Architect. In no case shall Drawings be scaled.

D. All subcontractors shall familiarize themselves with all of the conditions relating to this Contract since the terms set forth in the General Conditions binds all subcontractors to the Contract.

1.7 WORK LAYOUT

A. This contractor shall layout his work from construction lines and levels established by the General Contractor and shall be responsible for the proper location and placement of his work.

B. Maintain all bench marks, monuments, and other reference points; replace as directed if disturbed or destroyed.

1.8 PROTECTION OF STORED EQUIPMENT

A. Provide suitable storage for, and completely protect all materials and equipment prior to installation. Storage shall be dry, clean and safe. Any materials or equipment damaged,
deteriorated, rusted or defaced due to improper storage shall be fully repaired, refinished or replaced, as directed by the Engineer and any materials or equipment lost through theft or mishandling shall be replaced, all without additional cost to the Owner.

1.9 COORDINATION BETWEEN TRADES

A. Each Proposer shall review all drawings and specifications including Architectural, Mechanical, Electrical, Fire Protection, Landscaping, Structural, Surveys, etc., to insure that the work he intends to provide does not encroach a conflict with or affect the work of others in any way. Where such effect does occur it shall be the Proposer’s responsibility to satisfactorily eliminate any such encroachment conflict or effect prior to the submission of his proposal. Each Proposer shall in particular insure that there is adequate space to install his equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded to the Proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to insure adequate spaces.

B. It shall be the responsibility of this contractor to leave the necessary room for other trades. No extra compensation will be allowed to cover the cost of relocating conduit, boxes, etc., or equipment found encroaching on space required by others.

1.10 EQUIPMENT CONNECTIONS AND WIRING

A. This contractor shall make all electrical connections, etc., to equipment furnished by others whenever such equipment is shown on any part of the drawings or mentioned in any section of the specifications, unless otherwise specified.

B. Supervision, to assure proper functioning and operation shall be provided by the trade furnishing the equipment or apparatus so connected.

C. Unless otherwise specifically noted on the drawings or elsewhere in these specifications, all wiring shall be done by this contractor, including connections, etc., to all equipment requiring electrical services furnished under other sections of this specification. This contractor shall furnish and install all disconnects, overload protection, motor control apparatus, etc., for all equipment unless otherwise specifically noted elsewhere as being provided with, or as a part of, the equipment.

1.11 SUBSTITUTION OF MATERIALS AND EQUIPMENT

A. When this contractor requests approval of substitute materials and/or equipment, except when under formal alternate proposal, it shall be understood and agreed that such substitution, if approved, will be made without cost to the Owner or Engineer, regardless of changes in connections, spacing, electrical services, etc. In all cases where substitutions affect other trades, the contractor offering such substitutions shall reimburse all affected contractors for all necessary changes in their work.

1.12 CODES AND STANDARDS
A. Pertinent Federal, State and Local requirements and regulations are hereby made part of this contract. In case of conflict between Contract Documents and above listed requirements, the latter shall govern. Requirements of authority having local jurisdiction shall supersede all other requirements. Use of the term "code" in sections of the specification refers to applicable requirements and regulations of above agencies.

B. All electrical installation shall be made in accordance with the latest edition of the National Electrical Code and supplements in force at the time of bid opening, all materials employed shall bear Underwriters' official labels where such labeling is customary. In the event that local codes are more rigid than the National Electrical Code, both codes shall be considered as jointly governing and the requirements of either and/or both then prevail.

C. Following is a list of abbreviations for codes and standards, which are referred to in the specifications. Where such reference is made, the code or standard becomes a part of the specification as if the code or standard were included herein. Reference is always to the latest edition of the code or standard unless otherwise specifically noted.

1. Industry and Agency Standards, Codes and Specifications
   ANSI - American National Standards Institution
   ASTM - American Society of Testing and Materials
   NBFU - National Board of Fire Underwriters'
   NBS - National Bureau of Standards
   NEMA - National Electrical Manufacturers Association
   UL - Underwriters' Laboratories
   NEC - National Electrical Code
   NESC - National Electrical Safety Code
   IPCEA - Insulated Power Cable Engineers Association
   IEEE - Institute of Electrical and Electronics Engineers
   R56 - Motorola R56 Standards and Guidelines for Communications Sites
   NFPA 780 – Standard for the Installation of Lighting Protection Systems

D. Compliance with the Occupational Safety and Health Act shall be the responsibility of the contractor and under no circumstances shall the Engineer/Architect be an authority or be held responsible for any acts concerning this regulation.

1.13 MATERIALS AND EQUIPMENT

A. General. Material and equipment shall be furnished as specified in this section and in each individual electrical section of these specifications and shall be in strict accordance with the required ANSI, ASTM, NEMA, IPCEA, UL, NEC, or other recognized standards, codes and specifications listed. Applicable codes, standards and manufacturers' products referred to in these specifications shall establish minimum requirements for material, equipment and installation furnished.

B. Bolting shall be carbon steel conforming to ASTM A-307 with heavy hexagonal nut.

C. Angles, Channels, Beams, Bars and Rods shall be steel conforming to ASTM A-36.

1.14 INSTALLATION
A. Installation of all electrical equipment for the project as specified in these specifications and indicated on the drawings shall be in accordance with the general requirements of this section. Additional installation requirements applicable to individual systems are specified in the specific system section.

B. All equipment shall be installed at locations indicated on the drawings and as specified herein.

C. Assembly and installation of equipment shall be in strict accordance with manufacturer's installation instructions.

D. Equipment shall be securely anchored in place. Care shall be exercised to correctly orient equipment before securing in place.

E. All equipment and material shall meet the minimum requirements of seismic bracing as governed by the authority having jurisdiction.

1.15 OBSOLETE OR REMOVED EQUIPMENT AND MATERIALS

A. The Electrical Contractor shall remove all existing materials and equipment made obsolete by, and interfering with the additions, alterations, or razing as shown on the plans and specified. Maintain such existing equipment and materials intact and in existing condition insofar as possible.

B. Unless otherwise specifically stated in the specifications or shown on the drawings, all such removed material and equipment, not to be reused, shall be removed from the site and disposed of in a proper manner.

1.16 CONTINUOUS OPERATION AND CUT-OVER

A. The present services, facilities, or equipment shall be left intact until such time that the new permanent installation is completed or temporary means provided for continuous operation.

B. All new services, equipment, etc., for the new installation shall be installed complete to a point of connection before attempting to make new connections.

C. To facilitate the continuous operation of the system and building, the cut-over work shall be done at off-peak periods. Such periods shall be arranged by conference between the Contractor, Owner and the Engineer. All contractors shall rigidly adhere to the program so determined. Where critical communications equipment and or electronic switches are required to remain active to allow functionality of emergency systems or interconnections to other buildings, the contractor shall coordinate with the Owner for identification and make arrangements to keep this equipment operational.

D. All material installed shall meet the minimum requirements of the Local Code for seismic bracing and be installed in such a manner suitable for the seismic zone which applies.

1.17 TESTS
A. Following the completion of all wiring installation, test the individual systems and eliminate any existing grounding of potential conductors, short circuits, other faults, etc.

1.18 PERMITS, FEES AND CERTIFICATES

A. Each respective contractor shall obtain and pay all permits and licenses required by Federal, State and Local Ordinances for his type work. All fees in connection with inspections, permits, licenses and approvals shall be paid by the contractor whose work is affected.

B. All utility fees shall be included the contractor’s bid.

1.19 ELECTRICAL INSPECTION FOR CONTRACT COMPLIANCE

A. The contractor shall be responsible for obtaining and coordination of required electrical inspections and any fees and charges associated with the inspections. Inspections shall be made by an Electrical Inspector Certified by the authority having jurisdiction. The contractor shall furnish the Engineer and Owner a copy of the Electrical Certificate of approval before final payment will be made.

1.20 PROJECT CLEAN-UP

A. The Contractor shall export off site, all debris resulting from work under this Division. Burning of debris at the project site is not permitted.

B. Each contractor shall maintain his portion of this project in a neat and orderly fashion, disposing of debris, cartons, crates and boxes as the contents are installed in the project. This clean-up shall be accomplished each day in order not to create hardships on the other trades.

1.21 GUARANTEES AND WARRANTIES

A. This Contractor shall guarantee all equipment, apparatus, materials and workmanship entering into this contract to be the best of its respective kind, and shall replace all parts at his own expense, which have been proven defective, within one year from final acceptance of the work by the Owner. Items of equipment, which may have longer guarantees, shall have warranties and guarantees completed, in order, and in effect at the time of final acceptance of the work by the Architect. This contractor shall furnish all such warranties and guarantees at the time of final acceptance of the work.

1.22 SHOP DRAWINGS AND OTHER RELATED SUBMITTALS

A. Type submittal information required for each item of equipment shall be as scheduled at the end of this section.

B. Submittal data shall include specification data such as metal gauges, finish, optional accessories, etc., even though such equipment and materials may be detailed on the drawings or
specified. In addition, the submittal data shall include performance (certification) data, wiring diagrams where applicable, accurate dimensional drawings alone are not acceptable.

C. No roughing-in, connections, etc., shall be done until approved equipment submittals are in the hands of the contractors. It shall be the contractor's responsibility to obtain approved drawings and to make all connections, etc., in the neatest and most workmanship like manner possible. Each contractor shall coordinate with all other contractors having any connections, roughing-in, etc., to the equipment.

D. In general, normal catalog information (with the particular items underlined or otherwise denoted as being the submitted item) will be acceptable as submittal data. Installations, operating and maintenance instructions must be that information, specifically applicable to the item furnished ordinarily supplied with the equipment to the Owner with any modifications indicated. Wiring diagrams must be correct for the application. Generalized wiring diagrams, showing alternate methods of connection, will not be acceptable unless all unrelated sections are marked out. Submittal data sheets, which indicate several different model numbers, figure numbers, optional accessories, installation arrangements, etc., shall be clearly marked to indicate the specific items of equipment to be furnished. Samples and certificates shall be furnished as requested. Submittal data must be complete for each piece of equipment; piecemeal data will not be processed.

E. It shall be noted that approval of shop drawings by the Engineer applies only to general design, arrangement, type, capacity and quality. Such approval does not apply to quantities, dimensions, connection locations and the like. In all cases, the contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, that all equipment fits the available space in a satisfactory manner, and that all connections are suitably located.

F. Before the project is accepted, all submittal data (shop drawings, etc.) must be complete and approved. The Engineer will bind and furnish one set to the Owner for his records and files and one set will be retained. Duplicate information shall also be provided by means of electronic format.
### 1.23 ELECTRICAL DOCUMENT REQUIREMENTS

<table>
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<tr>
<th>ITEM OR DESCRIPTION OF EQUIPMENT REQUIRING SHOP DRAWINGS</th>
<th>P L A R T</th>
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1.24 OPERATION AND MAINTENANCE DATA

A. Submit four sets prior to final inspection bound in 8-1/2 x 11 inch text pages, three D side ring capacity expansion binders with durable plastic covers.

B. Prepare binder covers with printed title “OPERATION AND MAINTENANCE INSTRUCTIONS”. Title of project, and subject matter of binder when multiple binders are required.

C. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.

D. Contents: Prepare a Table of Contents for each volume, with each Product or system description identified, typed on 24-pound white paper.

E. Part 1: Directory, listing names, addresses, and telephone numbers of Architect/Engineer, Contractor, Subcontractors, and major equipment suppliers.

F. Part 2: Operation and maintenance instructions, arranged by system and subdivided. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:

1. Significant design criteria.
2. List of equipment
3. Parts list for each component.
4. Operating instructions.
5. Maintenance instructions for equipment and systems.
6. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

E. Part 3: Project documents and certificates, including the following:

1. Shop drawings and product data.
2. Power quality test results (including any required grounding tests).
3. Certificates.
4. Photocopies of warranties and bonds.

F. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection with Owner’s comments. Revise content of documents as required prior to final submittal.

G. Submit final volumes revised within ten days after final inspection.

1.25 TRAINING/INSTRUCTION

A. General Operating/Maintenance Instruction: Arrange for each installer of work requiring continuing maintenance or operation, to meet with the Owner’s personnel, at project site, to provide basic instructions needed for proper operation and maintenance of entire work. Include instructions by manufacturer’s representatives where installers are not expert in the required procedures. Review maintenance manuals, record documentations, tools, spare parts and materials, lubricants, fuels, identification system, control sequences, hazards, cleaning and similar procedures and facilities. For operational equipment, demonstrate start-up, shutdown, emergency operations, noise and vibration adjustments, safety, economy/efficiency adjustments, energy effectiveness, and similar operations. Review maintenance and operations in relation with applicable Warranties, Agreements to Maintain, Bonds, and similar continuing commitments.
B. Program Structure: Develop an instruction program that includes individual training modules for each system and equipment not part of a system, as required by individual Specification Sections, and as follows:

C. Training Modules: Develop a learning objective and teaching outline for each module. Include description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following:

1. Basis of System Design, Operational Requirements, and Criteria: Include system and equipment descriptions, operating standards, regulatory requirements, equipment function, operating characteristics, limiting conditions, and performance curves.
2. Documentation: Review emergency, operations, and maintenance manuals; Project Record Documents; identification systems; warranties and bonds; and maintenance service agreements.
3. Emergencies: Include instructions on stopping; shutdown instructions; operating instructions for conditions outside normal operating limits; instructions on meaning of warnings, trouble indications, and error messages; and required sequences for electric or electronic systems.
4. Operations: Include startup, break-in, control, and safety procedures; stopping and normal shutdown instructions; routine, normal, seasonal, and weekend operating instructions; operating procedures for emergencies and equipment failure; and required sequences for electric or electronic systems.
5. Adjustments: Include alignments and checking, noise, vibration, economy, and efficiency adjustments.
6. Troubleshooting: Include diagnostic instructions and test and inspection procedures.
7. Maintenance: Include inspection procedures, types of cleaning agents, methods of cleaning, procedures for preventive and routine maintenance, and instruction on use of special tools.
8. Repairs: Include diagnosis, repair, and disassembly instructions; instructions for identifying parts; and review of spare parts needed for operation and maintenance.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION 260000
SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves for raceways and cables.
2. Sleeve seals.
4. Common electrical installation requirements.

1.2 SUBMITTALS

A. Product Data: For sleeve seals.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

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

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
   b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.
B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Comply with all requirements of N.E.C. article 110 and others, which apply.

D. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

E. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

F. Right of Way: Give to piping systems installed at a required slope. Do not encroach equipment access areas, coordinate with all trades.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 6 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise. Adjust annular clear space pending method of fire stopping to be used.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in other sections of this specification or as indicated on the drawings.

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable
penetration sleeves with firestop materials. Comply with requirements in other sections of this specification or as indicated on the drawings.

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with architectural approved means or flexible boot-type flashing units applied in coordination with roofing work.

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

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in "Penetration Firestopping."

END OF SECTION 260500
SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.
   3. Sleeves and sleeve seals for cables.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Field quality-control test reports.

1.3 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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70.
B. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN.
C. Multi-conductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC with ground wire.

2.2 CONNECTORS AND SPLICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. AFC Cable Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

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

B. Coordinate sleeve selection and application with selection and application of firestopping specified in "Penetration Firestopping."

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTI-CONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

H. Lighting Fixture Whips: Type MC cable, length limited to 6'-0" maximum.

I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
J. Class 1 Control Circuits: Type THHN-THWN, in raceway.

K. Class 2 Control Circuits: Type THHN-THWN, in raceway when exposed, Power-limited cable, concealed in building finishes and Power-limited tray cable, in cable tray.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to "Identification for Electrical Systems."

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

H. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

I. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

END OF SECTION 260519
SECTION 260526A - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

1.2 SUBMITTALS

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

B. Field quality-control test reports.

C. Layout drawings showing the configuration of the grounding system shall be submitted to the Architect and Engineer for approval prior to installation.

D. Record drawings shall be submitted for the Owner’s use as part of the close out documents.

1.3 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. Comply with UL 467 and Motorola R56 Standards as a minimum for grounding and bonding materials and equipment. Manufacturer shall submit shop drawings for the entire grounding and lightning protection system. Refer to Drawings for additional requirements.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape or Bonding Conductor - terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.2 CONNECTORS
A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
   1. Pipe Connectors: Clamp type, sized for pipe.
C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES
A. Ground Rods: Copper; 3/4 inch diameter by 10 foot in length.

PART 3 - EXECUTION

3.1 APPLICATIONS
A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
B. Underground Grounding Conductors: Install bare copper conductor, No. 3/0 AWG tinned copper minimum. Bury at least 36 inches below grade and between 24 inches and 72 inches beyond the drip line of the building.
C. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded, except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Welded connectors.

3.2 EQUIPMENT GROUNDING
A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70 and Motorola R56:
   1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater and Heat-Tracing Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Signal and Communication Equipment: Refer to drawings for diagrams and details. For radio, racks, telephone, alarm, voice and data, and other communication equipment, provide grounding from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location. Interconnect to all applicable Sub-System Grounding Busbars (SSGB) and Signal Reference Grid System (SRGS).

E. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a suitably sized combination Main Grounding Bar/Exterior Grounding Busbar as indicated on drawings. Bond grounding busbar to counterpoise system. Refer to drawings for details.

F. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

G. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and extend bare tinned conductor to external counterpoise system, in addition to grounding conductor installed with branch-circuit conductors.

H. Ceiling Grid System: Bond grid system in the building to nearest available MBG, SSBG, IPGB or SRGS. Attach at each corner of each room at a minimum.

I. Light Fixtures: Bond housings of fixtures in the building. Bond to conductor used for associated lighting circuit and MBG, SSBG, IPGB or SRGS.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods as detailed and specified on drawings.
C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations and connections in raised flooring areas.

D. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use copper tape or bonding conductor jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each above ground portion of gas piping system downstream from equipment shutoff valve.

3.4 FIELD QUALITY CONTROL

A. When indicated on the drawings perform the following tests and inspections and prepare test reports:

1. After installing grounding system, but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.

   a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

   b. Perform tests by fall-of-potential method according to IEEE 81.

B. Report measured ground resistances that exceed the following values when required in part A:

1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 4ohms.
2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 4ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3ohms.
4. Power Distribution Units or Panel boards Serving Electronic Equipment: 1ohm(s).

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.
END OF SECTION 260526A
SECTION 260526B – SIGNAL REFERENCE GRID SYSTEM

PART 1 - GENERAL

1.1 Summary

A. Provide a complete grounding system that reduces or eliminates high frequency transients by achieving a common ground reference for all equipment within a contiguous area. It consists of a Signal Reference Grid, low-impedance bonding straps, transient suppression plates and bare copper bonding conductors. Refer to drawings for locations of Signal Reference Grid System.

B. The signal reference grid system shall be installed by a firm actively engaged in the installation of high frequency ground systems.

C. The work covered under this section of the specification consists of furnishing labor, materials and services required for the completion of a functional signal reference grid system approved by the architect and engineer.

1.2 References: The completed signal reference grid system shall comply with the latest issue of the following standards and form a part of this specification.

A. IEEE Std.1100, IEEE Recommended Practice for Powering and Grounding Electronic Equipment.

B. NFPA 70, National Electric Code and Motorola R56 Standards.

1.3 Submittals

A. Layout drawing(s) showing the configuration of the Signal Reference Grid shall be submitted to the Architect and Engineer for approval prior to installation. Refer to Drawings for additional requirements.

B. Catalog pages or technical data sheets for all products used to as part of the Signal Reference Grid System shall be submitted to the Architect and Engineer for approval prior to installation.

C. Record drawings shall be submitted for the Owner’s use as part of the close out documents.

1.4 Delivery, Storage and Handling

A. Store products in manufacturer’s unopened packaging until ready for installation.
PART 2 - Products

2.1 Standard

A. All materials used in the installation shall be new and shall comply in weight, size and composition as required by manufacturer and shall be labeled or listed by Underwriters Laboratories Inc. for use in electrical grounding. The system furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of high frequency grounding equipment.

2.2 Acceptable Manufacturers

A. Harger Lightning & Grounding
B. Erico
C. Approved equal

2.3 Materials

A. The Signal Reference Grid System (SRGS) shall be made from soft copper flat strip, 2 inches wide by 26gage, and factory-made using MIG welds on two-foot centers.
B. SRGS rolls shall be between 4 feet to 16 feet wide.
C. All field made connections to the Signal Reference Grid System (SRGS), raised floor pedestals, building columns, pipes and other metal items shall be made using the Ultraweld® Exothermic Welding Process.
D. The SRGS sections shall be rolled on tubes with the outside of the roll protected for shipment.
E. SRGS rolls shall be labeled on the ends for easy identification.

PART 3 - EXECUTION

3.1 General Installation

A. The installation shall be installed by a qualified, licensed electrical contractor.

3.2 SRGS Installation

A. SRGS sections shall be welded together using Ultraweld Mold SRG2016K with UWM32 Weld Metal and MH-1 Handle Clamp. For smokeless version add Suffix “SX” to mold and weld metal part numbers. To join sections together, overlap the outside strip of one section over the outside strip of the adjacent section and weld together every two feet.
B. The SRGS should be installed 6 inches to 18 inches from the outside walls to avoid interference with pedestals. SRGS does not have to be exactly centered between pedestals.

C. Whenever an obstruction is encountered, it is acceptable to cut the SRG to go around the obstruction and splice connecting pieces of the SRG to suit.

D. SRGS squares should not line up between adjacent sections in a room or between rooms. Offset as shown, first in one direction, then the other. This prevents welds from lying on top of one another and minimizes interference to pedestals.

E. The SRGS does not have to be bonded to the floor in most circumstances. If any section does not lie flat, pedestal mastic or other convenient means can be used to bond to the floor. Pedestal mastic should be used to hold the SRGS to the floor near high-speed air inlets. The mastic should not contain sulfur.

F. Do not use mastic until all SRGS mats have been installed and all Ultraweld connections between mats and all low impedance riser and pedestal connections have been made.

G. If a section of SRGS is damaged, then repair with Mold SRG2016K with UWM32 Weld Metal and MH-1 Handle Clamp. For smokeless version add Suffix “SX” to mold and weld metal part numbers. It is permissible to splice sections of copper strip to lengthen SRG conductors so they clear preexisting objects on floor.

H. Use Low Impedance Riser (LIR) to connect each equipment enclosure to the SRGS. Ultraweld Mold SRG2016K with UWM32 Weld Metal and MH-1 Handle Clamp is used for this connection. For smokeless version add Suffix “SX” to mold and weld metal part numbers.

I. LIR to be 26 gauge x 2” x 72 copper strip, Part No.LIR72. Do not connect LIR risers to SRG strips closest to outside walls. If possible, connect LIR no closer than the second SRG row away from outside walls of room.

J. Exceptions can be made regarding HVAC equipment if these are already positioned near walls. Cut LIR as short as possible in all cases.

K. Always install two LIRs per equipment cabinet with one LIR being 20% to 40% longer than the next and connect to the equipment on opposite sides.

3.3 Bonding Pedestals

A. Connect every sixth pedestal in each direction to the SRGS using #6 AWG 7 strand copper cable.

B. #6 AWG 7 strand copper is connected to the SRGS with Mold BCF61.5016B using UWM25 Weld Metal and MH-1 Handle Clamp.

C. For the 1” round pedestals, use Mold VHO61RDMX, MH-4 Handle Clamp, and UWM15 Weld Metal.

D. For the 7/8” square pedestals, use Mold VHO6.8SQMX, MH-4 Handle Clamp and UWM15 Weld Metal.
E. For the 1” square pedestals, use Mold VHO61SQMX, MH-4 Handle Clamp and UWM15 Weld Metal. 3.6. The cable should take the shortest path between the pedestal and the Signal Reference Grid. The length of the wire should not exceed 2 feet.

F. For smokeless version add Suffix “SX” to mold and weld metal part numbers.

3.4 Bonding Building Steel

A. All columns within and at perimeter of the room where the SRGS is installed shall be bonded to the SRGS using #6 AWG 7 strand copper cable with Mold VA6B, MH-1 Handle Clamp and UWM45 Weld Metal.

B. #6 AWG 7 strand copper is connected to the SRG with Mold BCF61.5016B using UWM25 Weld Metal and MH-1 Handle Clamp. The cable should take the shortest path between the building steel and the Signal Reference Grid.

C. For smokeless version add Suffix “SX” to mold and weld metal part numbers.

3.5 Bonding Other Steel Members

A. All conduits, water pipes, ducts, etc. entering the computer room shall be bonded to the SRG (at each end of the room if these are horizontal). Columns within and at perimeter of the computer room shall be bonded to the SRG using #6 AWG 7 strand copper cable with Mold VA6B, MH-1 Handle Clamp and UWM45 Weld Metal.

B. Use #6 AWG 7 strand copper cable.

C. Use Harger Lightning & Grounding CPC Series of pipe clamps for attaching the #6 wire to conduit, water pipes, and other round conductive members.

D. The #6 AWG 7 strand copper cable is connected to the SRGS with Mold BCF61.5016B using UWM25 Weld Metal and MH-1 Handle Clamp.

E. For smokeless version add Suffix “SX” to mold and weld metal part numbers.

3.6 Coordination

A. Coordinate the installation of the high frequency signal reference grid grounding system with other trades to avoid damage of installed materials.

END OF SECTION 260526B
SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.3 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

   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:

      a. Allied Tube & Conduit.
      b. Cooper B-Line, Inc.; a division of Cooper Industries.
      c. ERICO International Corporation.
      d. GS Metals Corp.
      e. Thomas & Betts Corporation.
      f. Unistrut; Tyco International, Ltd.
      g. Wesanco, Inc.

   2. Metallic Coatings: When installed in damp or wet locations. Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

4. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

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

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

           1) Hilti Inc.
           2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
           3) MKT Fastening, LLC.
           4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

   2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

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

           1) Cooper B-Line, Inc.; a division of Cooper Industries.
           2) Empire Tool and Manufacturing Co., Inc.
           3) Hilti Inc.
           4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
           5) MKT Fastening, LLC.

   3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

   4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

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

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS
A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
C. Field Welding: Comply with AWS D1.1.

3.4 CONCRETE BASES
A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in other sections of the contract documents.
C. Anchor equipment to concrete base.
   1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

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

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

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

END OF SECTION 260529
SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring. **Raceways shall be color coded for identification of Special Systems.** "Red" for fire alarm systems, "Green" for emergency power systems, "Blue" for UPS power systems, "Orange" for Voice/Data/Communications and "Yellow" for CCTV/Door Access Control systems. Normal power system is not required to be color coded.

B. "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks and manholes, and underground handholes, boxes, and utility construction.

1.2 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.3 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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1.

B. EMT: ANSI C80.3.

C. FMC: Zinc-coated steel.

D. LFMC: Flexible steel conduit with PVC jacket.

E. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.


2. Fittings for EMT: Compression type.
2.2 NONMETALLIC CONDUIT AND TUBING

A. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

B. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

2.3 METAL WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Cooper B-Line, Inc.
   2. Hoffman.
   3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1 or 3R, unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type NRMA 1 Flanged-and-gasketed type NEMA 3R.

E. Finish: Manufacturer's standard enamel finish.

2.4 BOXES, ENCLOSURES, AND CABINETS

A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, aluminum, Type FD, with gasketed cover.

C. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular as indicated on drawings.

D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

E. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.

F. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

G. Cabinets:
   1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
   1. Exposed Conduit: Rigid steel conduit or RNC, Type EPC-80-PVC where indicated on the drawings.
   2. Concealed Conduit, Aboveground: Rigid steel conduit unless indicated otherwise on the drawings.
   3. Underground Conduit: RNC, Type EPC-80-PVC, direct buried see other sections of the specifications for additional requirements.
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
   5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Comply with the following indoor applications, unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT or as indicated on the drawings.
   2. Exposed and Subject to Severe Physical Damage: Rigid steel conduit.
   3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
   5. Damp or Wet Locations: Rigid steel conduit, RNC when specifically indicated on the drawings.
   6. Concealed emerging from concrete: RMC.
   7. Raceways for Optical Fiber or Communications Cable: EMT.
   8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

C. Minimum Raceway Size: 1/2-inch trade size unless indicated otherwise.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
   1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of four 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceway Terminations: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

I. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire label both ends.

J. Raceways for Optical Fiber and Communications Cable: Install as follows:
   1. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
   2. Install with a maximum of two long sweep 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

K. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
   1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   2. Where otherwise required by NFPA 70.

L. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet.
   1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
      a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
      b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
      c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F temperature change.
      d. Attics: 135 deg F temperature change.
   2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.
3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

M. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors. Avoid use of flex for communications systems, except where installed in raised floor applications.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

N. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

O. Set metal floor boxes level and flush with finished floor surface.

P. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit.
2. Install backfill as specified in other sections of the specifications.
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand-tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in other sections of the specifications.
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
   b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
5. Warning Tape (ribbon): Bury warning tape approximately 12 inches above direct-buried conduits. Align tape along the width and along the centerline of conduit.

3.4 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in other sections of the specifications and on the drawings.
END OF SECTION 260533
SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Isolation pads.
2. Spring isolators.
3. Restrained spring isolators.
4. Channel support systems.
5. Restraint cables.
6. Hanger rod stiffeners.
7. Anchorage bushings and washers.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Building Occupancy Category as Defined in ASCE 7: IV.
2. Site Class as Defined in IBC: C.
3. Seismic Design Category as Defined in IBC: C.
4. Design Spectral Response Acceleration at Short Periods: .193
5. Design Spectral Response Acceleration at 1-Second Period: .093

1.3 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
   b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and
sealed by the qualified professional engineer responsible for their preparation. The professional engineer must be licensed/registered for the state that the project is located.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
   a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.

3. Field-fabricated supports.

4. Seismic-Restraint Details:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events.
   c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Welding certificates.

D. Field quality-control test reports.

E. Qualification Data: For professional engineer. The professional engineer must be licensed/registered for the state that the project is located.

1.4 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the 2007 Kentucky Building Code and ASCE Standard 7, unless requirements in this Section are more stringent.

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

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

D. Comply with NFPA 70.
PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

1. Amber/Booth Company, Inc.
3. Mason Industries.
4. Approved equal.

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

1. Resilient Material: Oil- and water-resistant neoprene, rubber, or hermetically sealed compressed fiberglass.

C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
2.2 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.
2. Cooper B-Line, Inc.; a division of Cooper Industries.
3. Hilti Inc.
5. Unistrut; Tyco International, Ltd.
6. Approved equal.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

D. Restraint Cables: ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.

F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

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

I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless
steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.2 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:
   1. Install restrained isolators on electrical equipment.
   2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole.
and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Obtain Engineer's approval before transmitting test loads to structure. Provide temporary load-spreading members.
2. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
3. Test to 90 percent of rated proof load of device.
4. Measure isolator restraint clearance.
5. Measure isolator deflection.
6. Verify snubber minimum clearances.
7. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.
3.6 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

<table>
<thead>
<tr>
<th>EQUIPMENT/SYSTEM TYPE</th>
<th>ISOLATOR TYPE</th>
<th>BASE TYPE</th>
<th>COMPONENT IMPORTANCE FACTOR ($I_p$)</th>
<th>COMPONENT AMPLIFICATION FACTOR</th>
<th>COMPONENT RESPONSE MODIFICATION FACTOR</th>
<th>SEISMIC RESTRAINT SYSTEM REQUIRED (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generators</td>
<td>NR</td>
<td>NA</td>
<td>1.5</td>
<td>1.0</td>
<td>2.5</td>
<td>Y</td>
</tr>
<tr>
<td>Transfer Switches</td>
<td>NR</td>
<td>NA</td>
<td>1.5</td>
<td>1.0</td>
<td>2.5</td>
<td>Y</td>
</tr>
<tr>
<td>Switchgear and Panelboard</td>
<td>NR</td>
<td>NA</td>
<td>1.5</td>
<td>2.5</td>
<td>6.0</td>
<td>Y. See Exemptions</td>
</tr>
<tr>
<td>Communication Equipment</td>
<td>NR</td>
<td>NA</td>
<td>1.5</td>
<td>1.0</td>
<td>2.5</td>
<td>Y. See Exemptions</td>
</tr>
<tr>
<td>Lighting Fixtures</td>
<td>NR</td>
<td>NA</td>
<td>1.5</td>
<td>1.0</td>
<td>1.5</td>
<td>Y. See Exemptions</td>
</tr>
<tr>
<td>Life-Safety Distribution Systems</td>
<td>NR</td>
<td>NA</td>
<td>1.5</td>
<td>1.0</td>
<td>2.5</td>
<td>Y</td>
</tr>
<tr>
<td>Conduit and Bus Ducts</td>
<td>NR</td>
<td>NA</td>
<td>1.5</td>
<td>1.0</td>
<td>2.5</td>
<td>Y. See Exemptions</td>
</tr>
<tr>
<td>Other Electrical Components</td>
<td>NR</td>
<td>NA</td>
<td>1.5</td>
<td>1.0</td>
<td>1.5</td>
<td>Y. See Exemptions</td>
</tr>
</tbody>
</table>

**LEGEND:**
- NA = Not Applicable
- NR = Not Required
- Y = Yes
- N = No

**A. Electrical Seismic-Restraint Exemptions:**

1. Electrical conduit in any Seismic Design Category where $I_p = 1.5$ and:
   a. Conduit is 2½ inch trade size or less.

2. Electrical trapeze assemblies (supporting conduit, bus duct, or cable tray) in any Seismic Design Category where $I_p = 1.5$ and:

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VIBRATION AND SEISMIC CONTROLS FOR
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a. Total weight of trapeze assembly weighs 10 lb/ft or less.

END OF SECTION 260548
SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Identification for conductors and control cable.
2. Warning labels and signs.
3. Equipment identification labels.

1.2 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

1.4 COORDINATION


PART 2 - PRODUCTS

2.1 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Marker Tape: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.2 WARNING LABELS AND SIGNS


B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Warning label and sign shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 mm)."

2.3 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and ultraviolet-resistant seal for label.

B. Screw attached, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray or black background. Minimum letter height shall be 3/8 inch.

PART 3 - EXECUTION

3.1 APPLICATION

A. Auxiliary Electrical Systems Conductor and Cable Identification: Use marker tape to identify field-installed alarm, control, signal, sound, intercommunications, voice, and data wiring connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and cable pull points. Identify by system and circuit designation.
2. Use system of designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

B. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
   a. Power transfer switches.
   b. Controls with external control power connections.

2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

C. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
   a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. 
      Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters 
      on 1-1/2-inch-high label; where 2 lines of text are required, use labels 2 inches 
      high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine label, drilled for 
      screw attachment.
   c. Elevated Components: Increase sizes of labels and legend to those appropriate for 
      viewing from the floor.

2. Equipment to Be Labeled:
   a. Panelboards, electrical cabinets, and enclosures.
   b. Electrical switchgear and switchboards.
   c. Transformers.
   d. Motor-control centers.
   e. Disconnect switches.
   f. Enclosed circuit breakers.
   g. Motor starters.
   h. Push-button stations.
   i. Power transfer equipment.
   j. Contactors.
   k. Wiring devices and Lighting Controls

3.2 INSTALLATION
A. Verify identity of each item before installing identification products.
B. Location: Install identification materials and devices at locations for most convenient viewing 
   without interference with operation and maintenance of equipment.
C. Apply identification devices to surfaces that require finish after completing finish work.
D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and 
   methods recommended by manufacturer of identification device.
E. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed 
   below for ungrounded service, feeder, and branch-circuit conductors.

1. Color shall be factory applied.
2. Colors for 208/120-V Circuits:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
3. Colors for 480/277-V Circuits:
b. Phase B: Orange.
c. Phase C: Yellow.

END OF SECTION 260553
SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following lighting control devices:
   1. Time switches.
   2. Outdoor photoelectric switches.
   3. Indoor occupancy sensors.
   4. Lighting contactors.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Field quality-control test reports.
C. Operation and maintenance data.

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Area Lighting Research, Inc.; Tyco Electronics.
   2. Grasslin Controls Corporation; a GE Industrial Systems Company.
   3. Intermatic, Inc.
   5. Lightolier Controls; a Genlyte Company.
   6. Lithonia Lighting; Acuity Lighting Group, Inc.
   8. Square D; Schneider Electric.
   9. TORK.
   10. Touch-Plate, Inc.
   11. Watt Stopper (The).
B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Configuration: DPST.
2. Contact Rating: 20-A ballast load, 120/240-V ac.
3. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
4. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
5. Astronomic Time: All channels.
6. Battery Backup: For schedules and time clock.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

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

1. Area Lighting Research, Inc.; Tyco Electronics.
2. Grasslin Controls Corporation; a GE Industrial Systems Company.
3. Intermatic, Inc.
4. Lithonia Lighting; Acuity Lighting Group, Inc.
5. Novitas, Inc.
7. Square D; Schneider Electric.
8. TORK.
9. Touch-Plate, Inc.
10. Watt Stopper (The).

B. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
2. Time Delay: 15-second minimum, to prevent false operation.
4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.3 INDOOR OCCUPANCY SENSORS

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

1. Hubbell Lighting.
3. Lithonia Lighting; Acuity Lighting Group, Inc.
4. Novitas, Inc.
5. RAB Lighting, Inc.
6. Sensor Switch, Inc.
7. TORK.
8. Watt Stopper (The).

B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. Mounting:
   a. Sensor: Suitable for mounting in any position on a standard outlet box.
   b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
   c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keep lighting off when selected lighting level is present.

C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.

1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot- high ceiling.

2.4 LIGHTING CONTACTORS

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:

2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
4. GE Industrial Systems; Total Lighting Control.
5. Grasslin Controls Corporation; a GE Industrial Systems Company.
6. Hubbell Lighting.
7. Lithonia Lighting; Acuity Lighting Group, Inc.
9. Square D; Schneider Electric.
10. TORK.
11. Touch-Plate, Inc.
12. Watt Stopper (The).

B. Description: Electrically operated and mechanically held combination type with non-fused
disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served,
including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or
less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the
point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA
type specified for the enclosure.

2.5 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12
AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power
Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multi-conductor cable with stranded-copper conductors not
smaller than No. 22AWG. Comply with requirements in Division 26 Section "Low-Voltage
Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multi-conductor cable with stranded-copper conductors not smaller than
No. 14AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical
Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas
indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

B. When requested within 12 months of date of Substantial Completion, provide on-site assistance
in adjusting sensors to suit actual occupied conditions.
3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with other sections of the specifications. Minimum conduit size shall be 3/4 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to other section of the specifications.
   1. Identify controlled circuits in lighting contactors.
   2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
   2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

END OF SECTION 260923
SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.

1.2 SUBMITTALS

A. Product Data: For each product type shown in the contract documents.

B. Shop Drawings: Indicate dimensions and weights.


C. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in the contract documents.

D. Field quality-control test reports.

E. Operation and maintenance data.

1.3 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. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. ACME Electric Corporation; Power Distribution Products Division.
2. Challenger Electrical Equipment Corp.; a division of Eaton Corp.
3. Controlled Power Company.
5. Federal Pacific Transformer Company; Division of Electro-Mechanical Corp.
9. Micron Industries Corp.
10. Myers Power Products, Inc.
13. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Brazed or pressure type.
   2. Coil Material: Aluminum.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified.

C. Cores: One leg per phase.

D. Enclosure: Ventilated, NEMA 250, Type 2.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Enclosure: Ventilated, NEMA 250 unless noted otherwise.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

F. Transformer Enclosure Finish: Comply with NEMA 250.
   1. Finish Color: Gray.

G. Taps for Transformers Smaller Than 3 kVA: One 5 percent tap above normal full capacity.
H. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

I. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

J. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

K. Energy Efficiency for Transformers Rated 15 kVA and Larger:
   1. Complying with NEMA TP 1, Class 1 efficiency levels.
   2. Tested according to NEMA TP 2.

L. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for non-sinusoidal load current-handling capability to the degree defined by designated K-factor indicated on the drawing.
   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
   2. Indicate value of K-factor on transformer nameplate.

M. Wall Brackets: Manufacturer's standard brackets.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate. Nameplates are specified in Division 26 Section "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
   1. Brace wall-mounting transformers as specified for seismic requirements as specified.

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and all other hanger and support requirements.

C. The Contractors shall verify and coordinate equipment dimensions with actual field conditions and other trades. It is the contractor’s responsibility to furnish all labor and material as required to adjust locations of equipment in order to comply with applicable codes and equipment access requirements; this will include but not be limited to modifications in feeder and branch circuit lengths. Final location of equipment shall be approved by the engineer.
3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections.

3.3 ADJUSTING

A. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.


END OF SECTION 262200
SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Service and distribution switchboards rated 600 V and less.
   2. Transient voltage suppression devices.
   3. Disconnecting and overcurrent protective devices.
   4. Instrumentation.
   5. Control power.
   6. Accessory components and features.
   7. Identification.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

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

1.3 SUBMITTALS

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

B. Shop Drawings: For each switchboard and related equipment.

   1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
   2. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.
   3. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Field quality-control reports.

E. Operation and maintenance data.
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. Comply with NEMA PB 2.

C. Comply with NFPA 70.

D. Comply with UL 891.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide Eaton Electrical Inc.; Cutler-Hammer Business Unit. or comparable product by one of the following:

2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

C. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
3. Sections front and rear aligned.

D. Nominal System Voltage: as noted on drawings.

E. Main-Bus Continuous: as noted on drawings.

F. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

G. Enclosure: Steel, NEMA 250, Type 1.
1. Enclosure Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

2. Enclosure: Flat roof; bolt-on rear covers for each section, with provisions for padlocking.

H. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

I. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

J. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
3. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

K. Phase and Neutral Buses and Connections: Three phase, four wire unless otherwise indicated. Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.

1. Ground Bus: 1/4-by-2-inch- minimum size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors.
2. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
3. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables.

L. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Surge Protection Device Description: Integrally mounted, see section 264313 for requirements.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating to meet available fault currents.


3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and \( I^2t \) response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
   c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   d. Ground-Fault Protection: Integral relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

2.4 ACCESSORY COMPONENTS AND FEATURES

A. Integral automatic transfer switch, fully rated, with features and in compliance with the requirements of “SECTION 263600 - TRANSFER SWITCHES” and include all features outlined within the product description thereof.

B. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.5 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, store and install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 3-1/2-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
   1. Set field-adjustable switches and circuit-breaker trip ranges.

G. Comply with NECA 1.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:
   1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. 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. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 262413
SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY
   A. Section includes distribution panelboards and lighting and appliance branch-circuit panelboards.

1.2 PERFORMANCE REQUIREMENTS
   A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to authorities having jurisdiction.
      1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.3 SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Shop Drawings: For each panelboard and related equipment.
      1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
      2. Detail enclosure types and details for types other than NEMA 250, Type 1.
      3. Detail bus configuration, current, and voltage ratings.
      4. Short-circuit current rating of panelboards and overcurrent protective devices.
      5. Include evidence of NRTL listing for series rating of installed devices.
      6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
      7. Include wiring diagrams for power, signal, and control wiring.
      8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.
   C. Field quality-control reports.
   D. Panelboard schedules for installation in panelboards.
   E. Operation and maintenance data.

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. Comply with NEMA PB 1.
C. Comply with NFPA 70.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Enclosures: Flush or Surface-mounted cabinets as indicated on the drawings.

1. Rated for environmental conditions at installed location.
   a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
   b. Outdoor Locations: NEMA 250, Type 3R.
   c. Kitchen and or Wash-Down Areas: NEMA 250, stainless steel.
   d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.


C. Incoming Mains Location: Top and bottom.

D. Phase, Neutral, and Ground Buses: Tin-plated aluminum.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

2. Main and Neutral Lugs: Mechanical type.
3. Ground Lugs and Bus Configured Terminators: Mechanical type.
4. Feed-Through Lugs (when indicated): Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, and listed and labeled for series-connected short-circuit rating by an NRTL.

2.2 DISTRIBUTION PANELBOARDS

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:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

C. Panelboards: NEMA PB 1, power and feeder distribution type.

D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

E. Mains: Circuit breaker.


H. Branch Overcurrent Protective Devices: Fused switches.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

C. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

D. Mains: Circuit breaker or lugs only as indicated.
E. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

G. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

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:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCl Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

f. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handles in on or off position.

g. Handle Clamp: Loose attachment, for holding circuit-breaker handles in on position.

2.5 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Surge Protection Device Description: Integrally mounted, see section 264313 for requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, store and install panelboards and accessories according to NEMA PB 1.1.

B. Mount top of trim 90 inches above finished floor unless otherwise indicated.

C. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

D. Install overcurrent protective devices and controllers not already factory installed.

   1. Set field-adjustable, circuit-breaker trip ranges.

E. Install filler plates in unused spaces.

F. Stub four 1-inch empty conduits from panelboards (with available space for future circuits) into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor spaces to allow installation of future circuitry.

G. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

H. Comply with NECA 1.

I. The Contractors shall verify and coordinate equipment dimensions with actual field conditions and other trades. It is the contractor’s responsibility to furnish all labor and material as required to adjust locations of equipment in order to comply with applicable codes and equipment access requirements; this will include but not be limited to modifications in feeder and branch circuit lengths. Final location of equipment shall be approved by the engineer.
3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads and incorporating Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified.

E. Panelboards will be considered defective if they do not pass tests and inspections.

END OF SECTION 262416
SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Receptacles, receptacles with integral GFCI, and associated device plates.
   2. Wall-box motion sensors.
   3. Snap switches and wall-box dimmers.
   4. Wall-switch.
   5. Communications outlets.

B. See Division 27 Section "Voice and Data Communication Cabling" for workstation outlets.

1.2 SUBMITTALS

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

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

1.3 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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

   1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
   2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
   4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).
2.2 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

2.4 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:

C. Pilot Light Switches, 20 A:

D. Key-Operated Switches, 120/277 V, 20 A:

1. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

2.5 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

1. 600 W; dimmers shall require no derating when ganged with other devices.

D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.
2.6 OCCUPANCY SENSORS

A. Wall-Switch Sensors (Stand Alone):

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
   a. Cooper.
   b. Hubbell.
   c. Leviton.
   d. Pass & Seymour.
   e. Watt Stopper (The).
   f. Sensor Switch, Inc.
   g. Lithonia Lighting; Acuity Lighting Group, Inc.

2. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft..

B. Ceiling Mounted-Switch Sensors (PIR and/or Ultra Sonic Type):

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
   a. Hubbell; ATD1600WRP.
   b. Leviton; ODW12-MRW.
   c. Watt Stopper (The); DT-200.

2. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft., where indicated on drawings.

2.7 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
3. Material for Unfinished Spaces: Galvanized steel for surface mounted boxes, smooth, high-impact thermoplastic recessed boxes.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable cover.

2.8 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.
1. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.
3. TVSS Devices: Orange
4. Wiring Devices Connected to UPS Power System: Blue

PART 3 - EXECUTION

3.1 INSTALLATION

A. Compile mounting heights listed in drawings, unless otherwise noted.

B. Coordination with Other Trades:
   1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
   1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

D. Device Installation:
   1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
   6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
   7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
   1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:
   1. Install dimmers within terms of their listing.
   2. Install unshared neutral conductors on line and load side of dimmers according to manufacturers’ device listing conditions in the written instructions.


3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Test Instruments: Use instruments that comply with UL 1436.
   2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:
   1. Line Voltage: Acceptable range is 105 to 132 V.
   2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.

END OF SECTION 262726
SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes individually mounted enclosed switches and circuit breakers, rated 600 V and less, used for disconnecting and protection functions.

1.02 SUBMITTALS
A. Product Data: For each type of switch and circuit breaker indicated.
B. Shop Drawings: Include wiring diagrams for shunt-tripped circuit breakers.
C. Field quality-control test reports.
D. Operation and maintenance data.

1.03 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. Source Limitations: Obtain switches and circuit breakers through one source from a single manufacturer.
C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 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:
   2. General Electric Co.; Electrical Distribution & Control Division.
   4. Square D Co.
   5. Approved equal.
2.02 ENCLOSED SWITCHES

A. Enclosed, Non-fusible Switch: NEMA KS 1, Type GD, with lockable handle, interlocked with cover.

B. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type GD, with clips to accommodate specified fuses, and lockable handle, interlocked with cover.

2.03 ENCLOSED CIRCUIT BREAKERS

A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
   3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
   1. Lugs: Suitable for number, size, trip ratings, and material of conductors.
   2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
   4. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

2.04 ENCLOSEURES

A. Listed for environmental conditions of installed locations, including:
   1. Outdoor Locations: NEMA 250, Type 3R.
   2. Food Service Areas: NEMA 250, Type 4X, stainless steel.
   3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   4. All other locations unless specified: NEMA 1.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Temporary Provisions: Remove temporary lifting provisions and blocking of moving parts.
B. Identify components; provide warning signs as specified in Division 16 Section "Basic Electrical Materials and Methods."

C. Furnish and install all enclosed switches and circuit breakers required for proper operation of all equipment specified in any part or shown in any part of the project construction documents with sizes and configuration based on the equipment manufactures data and applicable codes.

D. Install to allow required clearances per A.H.J.

3.02 FIELD QUALITY CONTROL

A. Testing: After installing disconnect switches and circuit breakers and after electrical circuits have been energized, demonstrate product capability and compliance with requirements.

B. Inspections and Tests for Switches and Circuit Breakers: Make internal and external inspections and perform tests, including the following:

1. Inspect for freedom from physical damage, proper unit rating, mechanical condition, enclosure integrity, cover operation, unit anchorage, clearances, and tightness of electrical connections. If a loose electrical connection is observed on any unit, check each electrical connection for each switch and circuit breaker with a torque wrench for compliance with manufacturer's torquing instructions.

C. Additional Inspections and Tests for Circuit Breakers: Include the following:

1. Inspect for proper frame, trip, and fault current interrupting rating.
2. Test shunt trip devices, circuits, and actuating components for proper operation.

D. Correct defective and malfunctioning units on-site, where possible, and re-inspect and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

END OF SECTION 232816
SECTION 263353 - THREE PHASE UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SUMMARY

This specification describes a three-phase, on-line, double conversion, solid state Uninterruptible Power System, hereafter referred to as the UPS. The UPS shall operate in conjunction with the existing building electrical system to provide high quality power conditioning, back-up power protection and distribution for electronic equipment loads. The system shall consist of a solid state inverter, power factor corrected rectifier, a 100% rated for continuous duty static switch, an internal maintenance bypass switch, battery plant, graphical status/control panel, and synchronizing circuitry as described herein.

1.2 STANDARDS

The UPS shall meet the requirements of the following standards:

A. UL listed under 1778, standards for uninterruptible power supply equipment

B. UL Canada (cUL)

C. FCC rules and regulations of part 15, subpart j, class A

D. IEC 1000 (801) level 4

E. The UPS shall be designed in accordance with the applicable sections of the documents published by:

2. National Electrical Manufacturer’s Association (NEMA)
3. Occupational Safety & Health Administration (OSHA)

1.3 SUBMITTALS

Submittals shall contain the following documentation:

A. Installation Package: Complete electrical characteristics and connection requirements. Provide detailed equipment outlines with cabinet dimensions and spacing requirements; location of conduit entry/exit paths; location of floor/seismic mounting; available battery types/sizes; all cabinet weights; heat rejection and air flow requirements; single-line diagram; control, and external wiring.

B. Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements.
C. Manufacturer’s Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product. Include equipment installation outline, connection diagram for external cabling, internal wiring diagram, and written instruction for installation.

1.4 FINAL SUBMITTALS

Upon delivery of the UPS system, the following submittals shall be included:

A. A complete set of installation drawings showing all the information stated in section 1.3.

B. An installation and users manual showing safe and correct operation of all UPS functions.

1.5 QUALIFICATIONS & QUALITY ASSURANCE

A. Manufacturer’s Certification: The manufacturer shall specialize in manufacturing of on-line, double conversion three phase UPS modules specified in this document with a minimum of twenty years documented experience, and with a nationwide first party service organization. The manufacturer shall be ISO 9001 certified and shall design to internationally accepted standards.

B. Factory Testing: Prior to shipment the manufacturer shall complete a documented test procedure to test all functions of the UPS module and batteries (via a discharge test), when supplied by the UPS manufacturer, and guarantee compliance with the specification. The factory test shall be performed in the presence of the customer providing the manufacturer receives adequate prior notice. The manufacturer shall provide a copy of the test report upon request.

C. Materials and Assemblies: All materials and parts comprising the UPS shall be new, of current manufacture, and shall not have been in prior service, except as required during factory testing. All active electronic devices shall be solid state and not exceed the manufacturer’s recommended tolerances for temperature or current to ensure maximum reliability. All semiconductor devices shall be sealed. All relays shall be provided with dust covers. The manufacturer shall conduct inspections on incoming parts, modular assemblies and final products.

1.6 DELIVERY, STORAGE, AND HANDLING

A. All products shall be packaged in a manner to prevent penetration by debris and to allow safe delivery by all modes of ground transportation and air transportation where specified.

B. Prior to shipping all products shall be inspected at the factory for damage.

C. Equipment shall be protected against extreme temperature and humidity and shall be stored in a conditioned or protected environment.

D. Equipment containing batteries shall not be stored for a period exceeding three months without powering up the equipment for a period of eight hours to recharge the batteries.

1.7 ENVIRONMENTAL REQUIREMENTS
The UPS shall operate under the following environmental conditions:

A. Temperature:

   UPS Module Operating:  0° to 40°C (32°F to 104°F)
   Non-Operating:        -20°C to +45°C (-4°F to 113°F)

B. Relative humidity (operating and storage): 0 to 95% non-condensing

C. Barometric Pressure:  Up to 1000 meters above sea level (up to 2000 meters with ambient temperature less than 28°C) / (up to 12,000 meters above sea level non operating)

D. Audible Noise: 67 dBA at 3 feet

1.8 WARRANTY

A. UPS Module: The UPS shall be covered by a full parts and labor warranty from the manufacturer for a period of twelve (12) months from date of installation or acceptance by customer or eighteen (18) months from date of shipment from the manufacturer, whichever occurs first.

B. Battery: The battery manufacturer’s warranty shall be passed through to the final customer and shall have a minimum period of one year.

1.9 SERVICE AND SPARE PARTS

A. The manufacturer shall, upon request, provide spare parts kits for the UPS module in a timely manner; as well as provide access to qualified factory trained first party service personnel to provide preventative maintenance and service on the UPS module when required.

1.10 MAINTENANCE, ACCESSIBILITY AND SELF DIAGNOSTICS

A. All UPS subassemblies, as well as the battery, shall be accessible from the front. UPS design shall provide maximum reliability and minimum MTTR (mean time to repair). To that end, the UPS shall be equipped with a self-test function to verify correct system operation. The self-test function shall identify the subassembly requiring repair in the event of a fault. The electronic UPS control and monitoring assembly shall therefore be fully microprocessor based, thus doing away with all potentiometer settings. This shall allow:

1. Auto-compensation of component drift;
2. Self-adjustment of replaced subassemblies;
3. Extensive acquisition of information vital for computer-aided diagnostics (local or remote);
4. Socket connection to interface with computer-aided diagnostics system.

B. The UPS shall be repairable by replacing standard subassemblies requiring no adjustments. Communication via a modem with a remote maintenance system shall be possible.

PART 2 - PRODUCTS

Murphy + Graves Architects
Project No. 1308
THREE PHASE UNINTERRUPTIBLE POWER SUPPLY
263353 - 3
2.1 APPROVED MANUFACTURERS & PRODUCT DESCRIPTION

A. Approved Manufacturer(s): The specified equipment will be manufactured by LIEBERT/EMERSON UPS SYSTEMS or approved manufacturer in compliance with specifications and as indicated on the drawings.

B. Product Description: This specification describes a three phase, double conversion, on-line, solid state Uninterruptible Power System, hereafter referred to as the UPS – refer to drawings for model number. The UPS shall operate in conjunction with the building electrical system to provide power conditioning, back-up power protection and distribution for electronic equipment loads. The system shall consist of a solid state IGBT PWM inverter, IGBT rectifier with a power factor corrected input, static switch, internal maintenance bypass switch, battery plant, graphical status/control panel, dry contact and communications ports, and synchronizing circuitry as described herein.

2.2 SYSTEM DESCRIPTION

A. UPS Design Requirements

1. Output Power Continuous Rating: The continuous output power rating of the UPS shall be sized for the KVA rating of Panel UPS-DP at a minimum of 0.8 lagging power factor – refer to Panel Schedule on E5.3 for loading. Units with higher power factors shall be permitted – adjust KVA ratings as required. Engineer reserves the right to determine final KVA rating during shop drawings.

2. Input Voltage: 208 VAC – 15% / +15%, 3 phase, 4 wire plus ground

3. Output voltage: 120/208 VAC 3 phase, 4 wire plus ground

4. Battery Autonomy: The UPS shall be capable of operating at full load for 9 minutes at 0.8 PF output at a temperature of 25°C on battery power

5. Battery Type: Valve regulated sealed lead acid (VRLA)

B. AC Input Characteristics

1. Voltage: 208 VAC, ±15%, 3 phase, 4 wire plus neutral plus ground

2. Frequency: 60 Hz (+8% / -25%)

3. Power Factor: < .99 lagging

4. Total Harmonic Distortion: Less than 3% at full load

5. Power walk-in: 0 to 100% over a 10-second period

6. Inrush Current: Less than nominal input current for less than one cycle

7. Input Surge Protection: The UPS is equipped with input MOVs to withstand surges per IEEE 587-1980/ANSI C62.41

C. AC Output Characteristics

1. Voltage: 208 VAC, ±15%, 3 phase, 3 wire plus neutral plus ground

2. Frequency: 60 Hz ±1% (or selectable up to 4%), 60 Hz ± 0.1% when free running

3. Voltage Regulation: ± 1.0% for balanced load

   ± 1.75 for 50% unbalanced load

   ± 2.5% for 100% unbalanced load
4. Voltage Distortion: Maximum 2% total (THD) and 1% any single harmonic on 100% linear loads
5. Voltage Transient (Step Load) Response: +3% for 50% step load change
   ±5% for 100% step load change
   ±1% for loss or return of AC input power or manual transfer at full load
6. Voltage Recovery Time: Return to within 1% of nominal value within 16.67 milliseconds (one cycle)
7. Phase Angle Displacement: 120° ± 1° for balanced load; 120° ± 3° for 100% unbalanced load
8. Non-Linear Load Capability: Output voltage total harmonic distortion shall be less than 3% when connected to a 100% non-linear load with a crest factor not to exceed 3%.
9. Slew Rate: 1 Hz/second maximum (or selectable up to 2.0 Hz/sec)
10. Power Factor: 0.8 at the rated volt-amperes (VA)
11. Inverter Overload Capability: 120% of rated load for 1 minute
    145% of rated load for 30 seconds
12. Bypass Overload Capability: >212% for one cycle; >150% for 30 seconds
13. Output voltage: 225A, 3 phase breaker

D. Battery
1. Battery Voltage: 198 VDC minimum before cutoff; 240 VDC nominal, 277 VDC maximum maintenance charge voltage; 300 VDC equalization voltage
2. Maximum DC Current: Maximum DC current at cutoff voltage will be 78 A.

2.3 MODES OF OPERATION

A. The UPS module shall be designed to operate as a double conversion, on-line reverse transfer system in the following modes.

B. Normal: The inverter shall continuously supply power to the critical load. The PFC rectifier shall derive power from the utility AC source and supply DC power to the inverter, while simultaneously float charging the battery.

C. Emergency: Upon failure of the utility AC power source, the critical load shall be supplied by the inverter, which, without any interruption, shall obtain its power from the battery.

D. Recharge: Upon restoration of the utility AC power source (prior to complete battery discharge), the PFC rectifier shall power the inverter and simultaneously recharge the battery.

E. Bypass Mode: The static bypass transfer switch shall be used to transfer the load to the bypass without interruption to the critical power load. This shall be accomplished by turning the inverter off. Automatic re-transfer or forward transfer of the load shall be accomplished by turning the inverter on.
F. Maintenance Bypass/Test Mode: A manual make before break internal maintenance bypass switch shall be provided to isolate the UPS inverter output and static bypass transfer switch for maintenance. This shall allow the UPS to be tested or repaired without affecting load operation.

2.4 COMPONENT DESCRIPTION

A. PFC Rectifier and Battery Charger

Incoming AC power shall be converted to a regulated DC output voltage by an IGBT (insulated gate bipolar transistor) power factor corrected (PFC) rectifier. The rectifier shall provide high quality DC power to charge the batteries and power the inverter and shall have the following characteristics:

1. Input Power Factor Correction (PFC): The PFC rectifier shall be power factor corrected so as to maintain an input power factor of 0.98 lagging to unity at all load levels to ensure generator compatibility and avoid reflected harmonics from disturbing loads sharing the utility power.

2. Input Harmonic Current Suppression: The PFC rectifier shall produce a sinusoidal input AC current on each phase with low harmonic content, limiting THD on the UPS input to below 3%. This shall eliminate the requirement for an input filter.

3. Modular Assembly: The PFC rectifier assembly shall be constructed of modular design to facilitate rapid maintenance.

4. Battery Charger Current Limiting: The UPS shall be equipped with a system designed to limit the battery recharge current (from 0.05 C10 to 0.1 C10).

5. Charging Levels: The ‘battery charging circuitry’ shall be capable of being set for automatic battery recharge operation, float service, manual battery charge service, and equalizing or commissioning operation.

6. Intermittent Charging: The battery charge level shall be maintained by an intermittent charging technique between two values Vfmin and Vfmax very close to the floating voltage. This technique shall be based on a cycle made up of a short charge period (a few seconds) from Vfmin to Vfmax followed automatically by a slow discharge period (a few minutes) from Vfmax to Vfmin. This cycle shall be repeated continuously to maintain the battery charge level. In this way the battery shall actually be charging only for a small part of the time, which considerably increases its service life.

7. Temperature Compensated Charging: The battery charger shall be equipped with a temperature probe to enable temperature compensated charging and adjust the battery float voltage to compensate for the ambient temperature using a negative temperature coefficient of 3 mV per cell per degree Celsius at a nominal temperature of 25°C.

8. Battery Capacity: The battery charger shall have sufficient capacity to support a fully loaded inverter and fully recharge the battery to 95% of its full capacity within 6-8 hours.

B. Inverter

The UPS output shall be derived from a Variable Frequency Pulse Width Modulated (PWM) IGBT inverter design. The inverter shall be capable of providing the specified precise output power characteristics (specified in section 2.2.C) while operating over the battery voltage range. The inverter assembly shall be constructed as a modular assembly to facilitate rapid maintenance.

C. Static Bypass – 100% Rated, Continuous Duty
The static bypass transfer switch shall be solid-state, rated for 100% continuous duty operation without mechanical contactor device in parallel for higher reliability and consistent response time and shall operate under the following conditions:

1. **Uninterrupted Transfer:** The static bypass transfer switch shall automatically cause the bypass source to assume the critical load without interruption after the logic senses one of the following conditions:
   a) Inverter overload exceeds unit's rating
   b) Battery protection period expired and bypass current is available
   c) Inverter failure

2. **Interrupted Transfer:** If the bypass source is beyond the conditions stated below, the UPS will make an interrupted transfer (not less than 100 msec. in duration).
   a) Bypass voltage greater than +10%, -10% from the UPS rated output voltage.
   b) Bypass frequency greater than ±2 Hz from the UPS rated output frequency.

3. **Automatic Uninterrupted Forward Transfer:** The static bypass transfer switch shall automatically forward transfer power, without interruption, after the UPS inverter is turned "ON" after an instantaneous overload-induced reverse transfer has occurred and the load current returns the UPS’s nominal rating or less.
4. **Manual Transfer:** A manual static transfer shall be initiated from the UPS Control Panel by turning the UPS inverter off.
5. **Overload Ratings:** The static bypass transfer switch shall have the following overload characteristics:
   a) 1000% of UPS output rating for 0.016 seconds (one cycle)
   b) 150% for 1 second
   c) 130% of UPS output rating for 1 minute

**D. Output Static Switch – 100% Rated, Continuous Duty**

UPS output shall be equipped with a 100% rated output static switch without mechanical contactor device in parallel for higher reliability and consistent response time of 16.66 msec.

**E. Microprocessor Controlled Logic**

The full UPS operation shall be provided through the use of microprocessor controlled logic. All operation and parameters are firmware controlled, thus eliminating the need for manual adjustments or potentiometers. The logic shall include a self-test and diagnostic circuitry such that a fault can be isolated down to the printed circuit assembly or plug-in power assembly level. Every printed circuit assembly or plug-in power assembly shall be monitored. Diagnostics shall be performed via a PC through the local diagnostics port on the UPS.

**F. Standard Display, Control and Indicator Panel**
The UPS will include a standard easy to use control and indicator panel. Included will be a backlit, color graphic animated LCD display and LED indicators. The UPS panel will include UPS “ON” and UPS “OFF” pushbuttons that will permit the user to safely command the UPS on or off without risk of load loss.

3.0 SYSTEM CONTROLS AND INDICATORS

A. Front Panel LCD Display: The UPS control panel shall provide a back-lit, color graphic display with choice of over 15 operating languages for indication of UPS status, metering, battery status, alarm/event log and advanced operational features. The display provides access to:

1. An animated, color mimic diagram indicating UPS power flow
2. Measurements, status indications and events
3. Bar-graphs and waveforms of the measured values
4. Personalization menu protected by a password, used to make specific settings
5. Event log with time stamping
6. Access to all measurements

System Parameters Monitored: The visual display will display the following system parameters based on true RMS metering:

Measurements:

1. Input voltage (Ph-Ph)
2. Input current per phase
3. Bypass voltage
4. Bypass input frequency
5. UPS output voltage (Ph-Ph and Ph-N) (3 phase simultaneously)
6. UPS output current per phase (3 phase simultaneously)
7. UPS output frequency
8. UPS output % load
9. UPS output kVA
10. UPS output power factor
11. Battery voltage
12. Crest factor
13. Battery current
14. Battery backup time and remaining service life
15. Battery temperature

Status Indications and Events:

1. Load on battery
2. Load on UPS
3. Load on automatic bypass
4. Low-battery warning
5. General alarm
6. Battery fault
7. Remaining back-up time during operation on battery power
8. Bypass source outside tolerances
9. Battery temperature
10. Additional indications shall provide maintenance assistance

Display of Operating Curves: The graphical display shall be capable of displaying curves and bar graphs of the above-mentioned measured values for significant periods.

Time-Stamped Historical Events: This function shall time-stamp and store all important status changes, anomalies, and faults, and make this information available for automatic or user-requested consultation.

B. LED Status Indicators: The UPS control panel shall provide three LEDs that signal the following status conditions:
1. Green LED: Load protected
2. Yellow LED: minor fault
3. Red LED: major fault, load not protected

C. On/Off Switch: The UPS shall provide the ON and OFF buttons to start and stop the inverter. The switch shall provide a built-in time delay to eliminate the risk of inadvertent operation (additional confirmation is requested). It is possible to remotely activate the OFF function via an isolated dry contact to create an emergency power off function resulting in:
1. Inverter shutdown
2. Opening of the automatic bypass
3. Opening of the input, bypass, output devices and battery circuit breaker
4. Opening of the isolated dry contact on the programmable relay card

D. Audible Alarm Reset: The UPS shall provide an audible alarm that can be stopped using the user interface. If a new alarm is sensed after the original alarm has been silenced, it will reactivate the audible alarm.

E. Emergency Power Off (EPO): The UPS shall be equipped with a local emergency power off button and dry contact input that can be used to command UPS shut down remotely. Activation of this command shall lead to the following actions:
1. Inverter shutdown
2. Opening of the static bypass switch and the battery circuit breaker
3. Opening of the input and output devices
4. Opening of an isolated dry contact on the programmable relay board

F. DB-9 Connector: One DB-9 connector with serial output will be provided for field diagnostics.

G. Dry Contacts: The UPS shall be provided standard with a programmable input/output relay board. This board shall have 8 dry contacts, i.e., 6 for input signals and 2 for output signals. Contacts shall be programmed as:
1. UPS on Line
2. Load on Bypass
3. UPS on Battery
4. UPS Battery Low
5. General alarm
6. Remote UPS on (input)
7. Remote UPS off (input)

The contacts will be normally open and will change state to indicate the operating status. The contacts will be rated at 2.0 A (250 VDC / 30 VDC).

PART 3 - EXECUTION

3.1 MECHANICAL DESIGN AND VENTILATION

A. Enclosure: The UPS shall be housed in a freestanding enclosure with dead front construction. The mechanical structure of the UPS shall be sufficiently strong and rigid to withstand handling and installation operations without risk. Access to UPS subassemblies shall be through the front or top. The sheet-metal elements in the structure shall be protected against corrosion by a suitable treatment, such as zinc electroplating, bichromating, epoxy paint or an equivalent.

B. Cable Access: The standard UPS available shall accommodate top and bottom entry cables.

C. Cabinet Weights and Dimensions: The width of the UPS is 33 (in inches) and has a maximum weight of 1500 (in lbs).

D. Ventilation and Heat Rejection: The UPS shall be designed for forced air-cooling. Air inlets shall be provided from the front bottom of the UPS enclosure. Air exhaust shall be from the top rear portion of the unit. Full load heat rejection is 12,295 BTU /hour.

3.2 BATTERY

The UPS module shall use a valve regulated sealed lead acid heavy-duty industrial battery designed for auxiliary power service in a UPS application. The primary battery shall be furnished with impact resistant plastic cases and housed in rack out containers inside the UPS module.

A. Protection Against Deep Discharge and Self-Discharge: The UPS shall be equipped with a device designed to protect the battery against deep discharge, depending on discharge conditions, with isolation of the battery by a circuit breaker. In particular, a monitoring device shall adjust the battery shutdown voltage as a function of a discharge coefficient to avoid excessive discharge at less than the rated output. A second device shall avoid self-discharge of the battery into the UPS control circuits during an extended shutdown of the UPS (over two hours).

B. Battery Self-Tests: The battery monitoring system shall be to perform the following automatic functions:

1. Battery circuit checks every twelve hours
2. Open-circuit battery test once a month
3. Partial discharge test every three months

This self-test system shall signal faults via LEDs on the front panel or a message to remote
supervision systems.

4.0 ACCESSORIES

A. External Control and Communications Devices

1. Network Management Card: The Network Management Card (NMC) shall provide a web interface, SNMP (Simple Network Management Protocol), logging, and email capabilities. The NMC shall be used for remote monitoring or graceful shutdown for most popular file servers.

B. Network Based Power Management Software:

1. Solution-Pac 2 software shall facilitate the management of the UPS over any point in a wide area network (WAN) or local area network (LAN). The software shall use a distributed, TCP/IP based architecture and must be SNMP manageable. To reduce the volume of network traffic, the software will employ trap reception acknowledgement. The software must be capable of graceful server shutdown of individual or multiple servers from any point on the network for up to 50 servers per card.

2. Enterprise Power Manager software shall facilitate the management of the UPS and servers over any point in a wide area network (WAN) or local area network (LAN). The software shall provide an overall, consolidated view of the main operating parameters of all power devices on the network. The information shall be accessible from any workstation using a standard web browser. The software shall use Secure Sockets Layer (SSL) and several levels of password protection for complete security. MGE network device required.

C. Internal Maintenance Bypass – The maintenance bypass provides for inside the enclosure to provide a wrap around bypass configuration for total UPS isolation during maintenance. Maintenance bypass transfers shall be without interruption and shall have mechanical keyed interlocks to protect the UPS from damage in the event of out of sequence transfers. An optional electrically based solenoid activated key release shall be available to control the removal of the keys from the key interlocks.

D. Remote Summary Alarm Panel: A wall mounted panel with five (5) indicating LED's shall display UPS status and any active alarms. The alarms shall be a latching type, such that if an alarm is triggered, the LED will stay ON (latch) even if the alarm is corrected. This feature will provide the operator the chance to verify the occurrence of the alarm. The parameters monitored and controls provided on the RSAP panel include:

1. UPS summary alarm (Red LED)
2. UPS on battery (Yellow LED)

The Remote Summary Alarm Panel shall also be equipped with:

a Alarm Test/Reset push-button: (white LED) to reset the latching alarm
a Audible Alarm: for alarm annunciation
a Audible Alarm reset push-button: (white LED) to silence the audible alarm

The RSAP door shall be equipped with a key lock. The recommended maximum distance from the UPS module shall be 500 feet.
Install remote annunciator at location coordinated with Owner.

5.0 FIELD QUALITY CONTROL & SERVICE ORGANIZATION

5.1 FIELD SERVICE ENGINEER QUALIFICATIONS

The manufacturer must employ a 7 X 24 nationwide field service organization with rapid access to all regions of the nation. The responding service professionals must be factory-trained engineers with an accredited and proven competence to service three phase UPS.

5.2 SPARE PARTS

Field Engineers must have immediate access to recommended spare parts with additional parts storage located in regional depots. Additional spare parts shall be accessible on a 7 x 24 basis from the national depot and must be expedited on a next available flight basis or via direct courier (whichever mode is quickest).

5.3 MAINTENANCE TRAINING

The manufacturer shall make available to the customer various levels of training ranging from basic UPS operation to UPS maintenance.

5.4 MAINTENANCE & SERVICE CONTRACTS

The manufacturer shall offer additional preventative maintenance and service contracts covering both the UPS and the battery bank. Accredited professional service engineers employed exclusively in the field of critical power systems service shall perform all maintenance and service. The manufacturer shall also offer extended warranty contracts.

END OF SECTION 263353
SECTION 264100 - FACILITY LIGHTNING PROTECTION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Furnish and install lightning protection system including the following:
   1. Integral air terminal system to protect the structure.
   2. Interconnecting lightning protection conductors.
   4. Lightning protection grounding electrode system.

1.2 PERFORMANCE REQUIREMENTS

A. Protect the entire building including roof projections, roof mounted equipment, associated exposed structures, electrical services, alarm services, and telecommunications services.

B. Design system based on a 150 ft lightning striking distance as defined in NFPA 780.

C. Design grounding system to achieve a ground resistance of not over 4 ohms – refer to soil resistivity report included in this specification section.

1.3 SUBMITTALS

A. Submit the following in accordance with the requirements of Division 26 Section "General Provisions for Electrical":
   1. Catalog data for each component of the lightning protection system, including data substantiating that material complies with specified requirements. Include data for roof adhesive when used.
   2. Certifications demonstrating that firms meet qualifications specified in "Quality Assurance" Article to demonstrate capabilities and experience. Include list of completed projects with project names, addresses, names of Architects and Owners, and other information specified.
   3. Materials list of lightning protection system components showing quantity and manufacturer's catalog number.
   4. Shop drawings, not smaller than 1/8" = 1'-0" scale, showing the type, size, and locations of counterpoise, ground rods, down conductors, through roof/through wall assemblies, roof conductors, air terminals, and bonding connections. Include details of air terminal base and cable fastener installations.
   5. Project record documents that accurately record actual locations of counterpoise, ground rods, down conductors, through roof/through wall assemblies, roof conductors, air terminals, and bonding connections.
   6. Test reports for all inspection and testing required by this Section.
1.4 QUALITY ASSURANCE

A. Comply with NFPA 780 Standard for the Installation of Lightning Protection Systems and UL 96A Installation Requirements for Lightning Protection Systems.

B. Engage a qualified installer to design and install the lightning protection system. Installer shall have either a current LPI Master Installer certification or current UL listing (Category OWAY) for Lightning Protection Installation. The installer shall have successfully completed not less than five (5) lightning protection installations of similar scope to this project.

C. The Engineer will inspect the lightning protection system for acceptance in accordance with NFPA 780 and UL 96A.

D. Provide products that are NRTL listed for lightning protection use.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate installation of lightning protection system with the installation of other building systems and components, including electrical wiring, supporting structures and building materials, and metal bodies requiring bonding to lightning protection systems.

B. Coordinate inspections so lightning protection conductors and bonding connections will be inspected and photographically documented before being covered with concrete or other building materials.

1.6 RECEIVING, STORING, AND PROTECTING

A. Receive, store, protect, and handle products according to NECA 1 Standard Practices for Good Workmanship in Electrical Construction.

B. Handle conductors to prevent nicking, kinking, gouging, flattening, or otherwise deforming or weakening conductor or impairing its conductivity.

PART 2 PRODUCTS

2.1 PRODUCT OPTIONS AND SUBSTITUTIONS

A. Alternate products may be accepted. 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.

B. LIGHTNING PROTECTION Material

C. Provide lightning protection materials and components that conform to NFPA 780 and UL 96 Standard for Safety for Lightning Protection Components.
D. Provide lightning protection materials that are galvanically compatible with each other and with surfaces on which they are mounted or which they contact. In general use copper conductors and bronze fittings; **use aluminum conductors and fittings only where required for galvanic compatibility.**

1. Metals acceptable for contact with copper include copper, nickel, brass, tin, lead, stainless steel, and Monel.
2. Metals acceptable for contact with aluminum include aluminum, magnesium, zinc, galvanized steel, stainless steel, lead, and wrought iron.
3. Provide conductors with protective coatings or oversize conductors where unusual conditions exist which would cause corrosion of conductors.

E. Air terminals:

1. Copper: Provide 1/2 inch-diameter, rounded-tip, solid-copper air terminals.
3. Air terminal tips shall have a tip radius of curvature of from 3/16 inch to 1/2 inch.
4. Provide a cast base for each air terminal that matches the air terminal material, has a bolted pressure type cable connector, will support the terminal in a vertical position, and is suitable for the surface to which it will be attached.

F. Conductors:

1. Copper Main Conductor: Provide copper cable with minimum 17 AWG strand size and a minimum cross sectional area of 115,000 circular mils.
2. Copper Bonding Conductor: Provide copper cable with minimum 17 AWG strand size and a minimum cross sectional area of 26,240 circular mils.

G. Provide bolted pressure type connectors; finger, crimp, or pressure saddle style cable connectors are not acceptable.

H. For installations on standing seam metal roofs provide air terminal bases and cable fasteners that clamp to the standing seams and are compatible with the roofing system and the lightning protection system materials.

I. Provide cast swivel couplings as required to install air terminals vertically.

J. For installations on membrane roofing or other surfaces that must not be penetrated provide attachments for air terminal bases and cable fasteners that do not depend on adhesive alone for proper performance.

1. Provide adhesives for cable fasteners and air terminal bases that are compatible with surface or roofing material to which bases or fasteners are to be attached.
2. Provide bases and fasteners that will stay in position and prevent overturning by using gravity or mechanical attachment.

2.2 GROUNDING SYSTEM MATERIAL

A. Ground Rods:
   1. Provide NRTL listed ground rods as determined by design.
   2. Furnish ground rods that comply with ANSI C135.30 with high-strength steel core and electrolytic-grade copper outer sheath, molten welded to core, approximately 10 feet long, 3/4 inches in diameter.
   3. Manufacturers: Blackburn, Thomas & Betts, Harger

B. Ground Cable:
   1. Provide bare stranded, soft temper copper cable that conforms to ASTM B8, Standard Specification for Concentric-Lay Stranded Copper Conductors.
   2. Provide cable size as specified in this Section, 1/0 AWG minimum.

C. Bolted Ground Connectors:
   1. Provide NRTL listed copper alloy bolted connectors with silicon bronze hardware for making cable connections to pipes, ground rods, exposed structural steel, roof deck, and wall panels.
   2. Manufacturers: Blackburn, Burndy, O.Z.

D. Exothermic Weld Connections:
   1. Provide molds and welding material in kit form for exothermic weld connections.
   2. Match mold and weld material to material types, shapes and sizes to be joined.
   3. Manufacturer: ERICO Cadweld

E. Compression Grounding Connectors:
   1. Provide NRTL listed wrought copper connectors, terminals and splices for making compression grounding connections on concentric lay ground electrode cable and bonding connections to reinforcing steel.
   2. Furnish connectors that have been tested successfully according to the requirements of IEEE Std. 837 - IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding.
   3. Provide hydraulic compression tools and dies that match the connectors.
   4. Match connector and die size to material shapes and sizes to be joined.
   5. Manufacturer: Blackburn, Burndy.

PART 3 EXECUTION

3.1 INSTALLATION - GENERAL

A. Install lightning protection system according to NFPA 780, UL 96A, the NEC and as specified in this Section.

B. Install lightning protection components according to manufacturer's written instructions.

C. Install air terminals on ridges, parapets, and around the perimeter of buildings with flat roofs at spacing not to exceed 20 feet. Install supplemental air terminals as required by
NFPA 780. Permanently and rigidly attach air terminals to prevent overturning. Install swivel adapters as required to position air terminals vertically.

D. On standing seam metal roofs use attachments for air terminal bases and cable fasteners that clamp to the standing seams.

E. On membrane roofing or other surfaces that must not be penetrated, attach air terminal bases and cable fasteners using materials and methods that do not depend on adhesive alone for proper performance. Coordinate with roofing material installer.

1. Acceptable installation methods on membrane roofs include:
   a. Mechanical fastening to nailer blocks that are pre-installed by the roofing subcontractor. Coordinate locations with the roofing subcontractor.
   b. Use approved top-fill ballast pans, 6-inch diameter for air terminals and 3-inch diameter for cable fasteners, which are filled with structural-density concrete then attached with adhesive to the membrane roof.

2. Use adhesives that are recommended by manufacturer of the cable fasteners and air terminal bases and are approved by manufacturer of the roofing material. Prepare roof surface and apply adhesives according to manufacturer's instructions.

F. Install roof conductors so they will be visible for inspection and testing.

G. Install down conductors at locations compatible with the building structure and architectural design with consideration given to the location of ground connections.

   1. Install concealed down conductors on building structural columns. Make connections from roof conductors to down conductors on parapet walls; avoid using through-roof connectors.

H. Install an accessible down conductor disconnect in each down conductor except the one nearest the building electrical service entrance; use 4-bolt tubular splice fittings.

I. Cover down conductors that are subject to physical damage or displacement with Schedule 80 PVC conduit. Cover down conductors from grade level up to 6 ft above grade. Support conduit with conduit clamps spaced not more than 36 inches apart.

3.2 LIGHTNING PROTECTION GROUNDING ELECTRODE SYSTEM

A. Counterpoise Electrode: Install a counterpoise ring around the building. Use minimum 1/0 AWG ground cable located 5 ft outside the building perimeter and at least 6 ft from any electrical system or communications system grounding. Install the counterpoise at least 3 ft below grade. Encase the counterpoise in a 2 inch envelope of ground electrode backfill material slurry.

B. Connect the counterpoise to the main grounding electrode ground bar located near the building electrical service entrance. Interconnections to electrical power, telephone, and piping systems will be made at the main grounding electrode ground bar.
3.3 LIGHTNING PROTECTION CONNECTIONS

A. Clean contact surfaces to which lightning protection connections are to be made. Remove non-conductive coatings such as paint, enamel, and oil film.

B. Use the following connection methods:
   1. Use exothermic weld connections for underground or concealed connections of dissimilar materials.
   2. Use exothermic weld or compression grounding connections for underground or concealed connections of like materials. Do not use compression grounding connectors for rope lay lightning conductor connections or for lightning protection ground rod connections.
   3. Use exothermic weld or bolted connections for accessible connections.
   4. Use high strength silicon bronze bolts, nuts, flat washers and toothed lockwashers for making bolted connections.

C. Tighten lightning protection connectors, screws and bolts in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with UL 486A and UL 486B. Use a calibrated torque wrench.

D. Use hydraulic compression tools to provide the correct circumferential pressure for compression connectors. Use tools and dies recommended by the manufacturer of the connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed.

E. Install exothermic welds in accordance with manufacturer's instructions and recommendations. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

F. Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
   1. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.
   2. Make connections with clean bare metal at points of contact.
   3. Make aluminum to steel connections with stainless steel separators and mechanical clamps.
   4. Make aluminum to galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
   5. Coat and seal connections involving dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

G. Protect lightning protection connections to prevent them from being painted or covered with material such as fire proofing or roofing adhesive.
3.4 FIELD QUALITY CONTROL

A. Use test instruments that are capable of measuring within plus or minus 10 percent of the required reading and have current calibration.

B. Test the lightning protection grounding electrode system using the “fall of potential” method. Make test at least 30 days after installation of the electrode and before any connections are made to the electrode. Verify that resistance to earth reading is 25 ohms or less. Supplement grounding electrode if resistance exceeds 25 ohms. Use test instruments that are designed specifically for earth resistance testing. Provide certified test results and instrument calibration information to the Engineer.

C. Inspect and test the lightning protection system to determine:
   1. That the system complies with the current requirements of NFPA 780.
   2. That all required bonds are in place and are secure.
   3. That all AC power lines, communications, and data lines that enter the facility have surge suppression devices that are properly installed and functional.

Take corrective action to correct deficiencies. Provide certified inspection and test results and instrument specifications and calibration information to the Engineer.
September 26, 2012

Honorable Buzz Carioftis, Judge Executive
Rockcastle County Fiscal Court
205 East Main Street
Mt. Vernon, Kentucky 40456

RE: Soil Resistivity Addendum Letter
Rockcastle County Emergency Operations Center
Mt. Vernon, Kentucky
AEI Project No. 212-205

Dear Judge Carioftis:

American Engineers, Inc. (AEI) is pleased to submit this additional letter encompassing the soil resistivity testing for the above referenced site.

AEI was on site September 6, 2012 to perform soil resistivity testing to provide parameter for design of the grounding system for the communications tower supporting the emergency operations center. The soil resistivity testing was performed approximate to the proposed tower location and Boring B-1 using a Miller 400D Digital Resistance Meter. Resistivity testing included five lines surrounding the proposed tower following test method IEEE Standard 81 (Wenner 4-pt Method). The following table includes the apparent soil resistivity based on depth.

<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Apparent Resistivity (Ω-cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>10,590</td>
</tr>
<tr>
<td>10</td>
<td>10,161</td>
</tr>
<tr>
<td>20</td>
<td>14,531</td>
</tr>
</tbody>
</table>

Typical values for clay soils range from 200 to 15,000 Ω-cm according to USDA data. Soil resistivity typically decreases with increased water content and increases with decreases in temperature.

Respectfully,

AMERICAN ENGINEERS, INC.

Dusty Barrett, PE
Geotechnical Engineer

Dennis Mitchell, PE
Director of Geotechnical Services

www.aei.cc
Glasgow, KY • Marietta, GA • Louisville, KY
SECTION 264313 - SURGE PROTECTIVE DEVICES (SPDs)

PART 1 - GENERAL

1.1 SCOPE

A. The Contractor shall furnish and install the Surge Protective Device (SPD) equipment having the electrical characteristics, ratings, and modifications as specified herein and as shown on the contract drawings. To maximize performance and reliability and to obtain the lowest possible let-through voltages, the ac surge protection shall be integrated into electrical distribution equipment such as switchgear, switchboards, panelboards, busway (integrated within bus plug), or motor control centers. Refer to related sections for surge requirements in:

1.2 REFERENCES

A. SPD units and all components shall be designed, manufactured, and tested in accordance with the latest applicable UL standard (ANSI/UL 1449 3rd Edition).

1.3 SUBMITTALS – For Review/Approval

A. The following information shall be submitted to the Engineer:

1. Provide verification that the SPD complies with the required ANSI/UL 1449 3rd Edition listing by Underwriters Laboratories (UL) or other Nationally Recognized Testing Laboratory (NRTL). Compliance may be in the form of a file number that can be verified on UL’s website or on any other NRTL’s website, as long as the website contains the following information at a minimum: model number, SPD Type, system voltage, phases, modes of protection, Voltage Protection Rating (VPR), and Nominal Discharge Current ($I_n$).

2. For sidemount mounting applications (SPD mounted external to electrical assembly), electrical/mechanical drawings showing unit dimensions, weights, installation instruction details, and wiring configuration.

B. Where applicable the following additional information shall be submitted to the engineer:

1. Descriptive bulletins

2. Product sheets

1.4 Submittals – for Construction

A. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed in Section 1.04 and shall incorporate all changes made during the manufacturing process
1.5 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

1.6 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer’s instructions. One (1) copy of manufacturer’s instructions shall be included with the equipment at time of shipment.

1.7 OPERATION AND MAINTENANCE MANUALS

A. Operation and maintenance manuals shall be provided with each SPD shipped.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Retain above for nonproprietary or below for semi-proprietary specification. Refer to Division 01 Section "Product Requirements."
2. Advanced Protection Technologies, Inc.
3. Atlantic Scientific.
8. Innovative Technology, Inc.
9. Intermatic, Inc.
10. LEA International.
12. Liebert Corporation; a division of Emerson.
15. Square D; Schneider Electric.
17. Sutton Designs Inc.
18. Transtector Systems, Inc.
19. Tycor; Cutler-Hammer, Inc.

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features, and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

2.2 VOLTAGE SURGE SUPPRESSION – GENERAL

A. Electrical Requirements

1. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
2. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 115% of the nominal system operating voltage.
3. The suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.
4. Protection Modes – The SPD must protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

<table>
<thead>
<tr>
<th>Protection Modes</th>
<th>L-N</th>
<th>L-G</th>
<th>L-L</th>
<th>N-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wye</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Delta</td>
<td>N/A</td>
<td>●</td>
<td>●</td>
<td>N/A</td>
</tr>
<tr>
<td>Single Split Phase</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>High Leg Delta</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

5. Nominal Discharge Current ($I_n$) – All SPDs applied to the distribution system shall have a 20kA $I_n$ rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an $I_n$ less than 20kA shall be rejected.
6. ANSI/UL 1449 3rd Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 3rd Edition VPR for the device shall not exceed the following:

<table>
<thead>
<tr>
<th>Modes</th>
<th>208Y/120</th>
<th>480Y/277</th>
<th>600Y/347</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-N; L-G; N-G</td>
<td>700</td>
<td>1200</td>
<td>1500</td>
</tr>
<tr>
<td>L-L</td>
<td>1200</td>
<td>2000</td>
<td>3000</td>
</tr>
</tbody>
</table>
B. SPD Design

1. Maintenance Free Design – The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.

2. Balanced Suppression Platform – The surge currents shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules shall not be accepted.

3. Electrical Noise Filter – Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method. Products unable to meet this specification shall not be accepted.

4. Internal Connections – No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.

5. Monitoring Diagnostics – Each SPD shall provide the following integral monitoring options:

   a. Protection Status Indicators - Each unit shall have a green / red solid-state indicator light that reports the status of the protection on each phase.

      1) For wye configured units, the indicator lights must report the status of all protection elements and circuitry in the L-N and L-G modes. Wye configured units shall also contain an additional green / red solid-state indicator light that reports the status of the protection elements and circuitry in the N-G mode. SPDs that indicate only the status of the L-N and L-G modes shall not be accepted.

      2) For delta configured units, the indicator lights must report the status of all protection elements and circuitry in the L-G and L-L modes.

      3) The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.

   b. Remote Status Monitor – The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.

   c. Audible Alarm and Silence Button – The SPD shall contain an audible alarm that will be activated under any fault condition. There shall also be an audible alarm silence button used to silence the audible alarm after it has been activated.

   d. Surge Counter – The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location. The surge counter shall
trigger each time a surge event with a peak current magnitude of a minimum of 50 ± 20A occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total.

1) The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter’s display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter’s memory shall not require a backup battery in order to achieve this functionality.

6. Overcurrent Protection

a. The unit shall contain thermally protected MOVs. These thermally protected MOVs shall have a thermal protection element packaged together with the MOV in order to achieve overcurrent protection of the MOV. The thermal protection element shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.

7. Fully Integrated Component Design – All of the SPD’s components and diagnostics shall be contained within one discrete assembly. SPDs or individual SPD modules that must be ganged together in order to achieve higher surge current ratings or other functionality shall not be accepted.

8. Safety Requirements

a. The SPD shall minimize potential arc flash hazards by containing no user serviceable / replaceable parts and shall be maintenance free. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.

b. SPDs designed to interface with the electrical assembly via conductors shall require no user contact with the inside of the unit. Such units shall have any required conductors be factory installed.

c. Sidemount SPDs shall be factory sealed in order to prevent access to the inside of the unit. Sidemount SPDs shall have factory installed phase, neutral, ground and remote status contact conductors factory installed and shall have a pigtail of conductors protruding outside of the enclosure for field installation.

2.3 SYSTEM APPLICATION

A. The SPD applications covered under this section include distribution and branch panel locations, busway, motor control centers (MCC), switchgear, and switchboard assemblies. All SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C, B, and A environments.
B. Surge Current Capacity – The minimum surge current capacity the device is capable of withstanding shall be as shown in the following table:

<table>
<thead>
<tr>
<th>Category</th>
<th>Application</th>
<th>Per Phase</th>
<th>Per Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Service Entrance Locations (Switchboards, Switchgear, MCC, Main Entrance)</td>
<td>250 kA</td>
<td>125 kA</td>
</tr>
<tr>
<td>B</td>
<td>High Exposure Roof Top Locations (Distribution Panelboards)</td>
<td>160 kA</td>
<td>80 kA</td>
</tr>
<tr>
<td>A</td>
<td>Branch Locations (Panelboards, MCCs, Busway)</td>
<td>120 kA</td>
<td>60 kA</td>
</tr>
</tbody>
</table>

C. SPD Type – all SPDs installed on the line side of the service entrance disconnect shall be Type 1 SPDs. All SPDs installed on the load side of the service entrance disconnect shall be Type 1 or Type 2 SPDs.

2.4 Lighting and Distribution Panelboard Requirements

A. The SPD application covered under this section includes lighting and distribution panelboards. The SPD units shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category B environments.

1. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.
2. SPDs shall be installed immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
3. The panelboard shall be capable of re-energizing upon removal of the SPD.
4. The SPD shall be interfaced to the panelboard via a direct bus bar connection. Alternatively, an SPD connected to a 30A circuit breaker for disconnecting purposes may be installed using short lengths of conductors as long as the conductors originate integrally to the SPD. The SPD shall be located directly adjacent to the 30A circuit breaker.
5. The SPD shall be included and mounted within the panelboard by the manufacturer of the panelboard.
6. The SPD shall be of the same manufacturer as the panelboard.
7. The complete panelboard including the SPD shall be UL67 listed.

B. Switchgear, Switchboard, MCC and Busway Requirements

1. The SPD application covered under this section is for switchgear, switchboard, MCC, and busway locations. Service entrance located SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C environments.
2. The SPD shall be of the same manufacturer as the switchgear, switchboard, MCC, and busway.
3. The SPD shall be factory installed inside the switchgear, switchboard, MCC, and/or bus plug at the assembly point by the original equipment manufacturer.
4. Locate the SPD on the load side of the main disconnect device, as close as possible to the phase conductors and the ground/neutral bar.
5. The SPD shall be connected through a disconnect (30A circuit breaker). The disconnect shall be located in immediate proximity to the SPD. Connection shall be made via bus, conductors, or other connections originating in the SPD and shall be kept as short as possible.
6. The SPD shall be integral to switchgear, switchboard, MCC, and/or bus plug as a factory standardized design.
7. All monitoring and diagnostic features shall be visible from the front of the equipment.

2.5 Enclosure S

A. All enclosed equipment shall have NEMA 1 general purpose enclosures, unless otherwise noted. Provide enclosures suitable for locations as indicated on the drawings and as described below:

1. NEMA 1 – Constructed of a polymer (units integrated within electrical assemblies) or steel (sidemount units only), intended for indoor use to provide a degree of protection to personal access to hazardous parts and provide a degree of protection against the ingress of solid foreign objects (falling dirt).
2. NEMA 4 – Constructed of steel intended for either indoor or outdoor use to provide a degree of protection against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (dirt and windblown dust); to provide a degree of protection with respect to the harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose directed water); and that will be undamaged by the external formation of ice on the enclosure. (sidemount units only)
3. NEMA 4X – Constructed of stainless steel providing the same level of protection as the NEMA 4 enclosure with the addition of corrosion protection. (sidemount units only)

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA and UL standards.

3.2 INSTALLATION

A. The Contractor shall install all equipment per the manufacturer's recommendations and the contract drawings.
3.3 WARRANTY

A. The manufacturer shall provide a full ten (10) year warranty from the date of shipment against any SPD part failure when installed in compliance with manufacturer's written instructions and any applicable national or local code.

END OF SECTION 264313
SECTION 265100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

B. See other sections of the specifications for control devices.

1.2 SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes.

B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.

C. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.

D. Field quality-control test reports.

1.3 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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Basis-of-Design Product: The design for each lighting fixture is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by another manufacturer. IES files shall be furnished to the Engineer.
upon request for comparisons. Fixtures which do not have documented IES files shall not be acceptable.

2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

C. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

G. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.
   4. Laminated Silver Metallized Film: 90 percent.

H. Plastic Diffusers, Covers, and Globes:
   1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
      a. Lens Thickness: At least 0.125 inch minimum unless different thickness is indicated.
      b. UV stabilized.
   2. Glass: Annealed crystal glass, unless otherwise indicated.

2.3 BALLASTS

A. Electronic Ballasts for Linear Fluorescent Lamps: Comply with ANSI C82.11; instant-start type, unless otherwise indicated, and designed for type and quantity of lamps served. Ballasts shall be designed for full light output unless dimmer or bi-level control is indicated.
   1. Sound Rating: A.
   2. Total Harmonic Distortion Rating: Less than 20 percent.
3. Transient Voltage Protection: IEEE C62.41, Category A or better.
4. Operating Frequency: 42 kHz or higher.
5. Lamp Current Crest Factor: 1.7 or less.
6. BF: 0.85 or higher.
7. Power Factor: 0.98 or higher.

B. Ballasts for Dimmer-Controlled Lighting Fixtures with Linear Fluorescent Lamps: Electronic type.
   1. Dimming Range: 100 to 5 percent of rated lamp lumens.
   2. Ballast Input Watts: Can be reduced to 20 percent of normal.
   3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

C. Ballasts for Bi-Level Controlled Lighting Fixtures with Linear Fluorescent Lamps: Electronic type.
   1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
      a. High-Level Operation: 100 percent of rated lamp lumens.
      b. Low-Level Operation: 50 percent of rated lamp lumens.
   2. Ballast shall provide equal current to each lamp in each operating mode.
   3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

D. Ballasts for Compact Fluorescent Lamps: Electronic programmed rapid-start type, complying with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:
   1. Lamp end-of-life detection and shutdown circuit.
   2. Automatic lamp starting after lamp replacement.
   3. Sound Rating: A.
   4. Total Harmonic Distortion Rating: Less than 20 percent.
   5. Transient Voltage Protection: IEEE C62.41, Category A or better.
   6. Operating Frequency: 20 kHz or higher.
   7. Lamp Current Crest Factor: 1.7 or less.
   8. BF: 0.95 or higher, unless otherwise indicated.
   9. Power Factor: 0.98 or higher.
   10. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.

E. Ballasts for Dimmer-Controlled Lighting Fixtures with Compact Fluorescent Lamps: Electronic type.
   1. Dimming Range: 100 to 5 percent of rated lamp lumens.
   2. Ballast Input Watts: Can be reduced to 20 percent of normal.
   3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.
F. **Internal-Type Emergency Fluorescent Power Unit:** Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.

1. **Emergency Connection:** Operate 2 fluorescent lamp(s) continuously at an output of lumens each as indicated on the drawings. Connect un-switched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. **Night-Light Connection:** Operate one fluorescent lamp continuously.
3. **Test Push Button and Indicator Light:** Visible and accessible without opening fixture or entering ceiling space.
   a. **Push Button:** Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   b. **Indicator Light:** LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
4. **Battery:** Sealed, maintenance-free, nickel-cadmium type.
5. **Charger:** Fully automatic, solid-state, constant-current type with sealed power transfer relay.

G. **Electromagnetic Ballast for Metal-Halide Lamps:** Comply with ANSI C82.4 and UL 1029. Include the following features, unless otherwise indicated:

1. **Ballast Circuit:** Constant-wattage autotransformer or regulating high-power-factor type.
2. **Minimum Starting Temperature:** Minus 22 deg F for single-lamp ballasts.
3. **Normal Ambient Operating Temperature:** 104 deg F.
4. **Open-circuit operation that will not reduce average life.**
5. **Low-Noise Ballasts:** Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.

H. **Electronic Ballast for Metal-Halide Lamps:** Include the following features unless otherwise indicated:

1. **Lamp end-of-life detection and shutdown circuit.**
2. **Sound Rating:** A.
3. **Total Harmonic Distortion Rating:** Less than 15 percent.
4. **Transient Voltage Protection:** IEEE C62.41, Category A or better.
5. **Lamp Current Crest Factor:** 1.5 or less.
6. **Power Factor:** .90 or higher.
7. **Interference:** Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
8. **Protection:** Class P thermal cutout.

2.4 **EXIT SIGNS**

A. **Internally Lighted Signs:** Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

1. **Lamps for AC Operation:** LEDs, 70,000 hours minimum rated lamp life.
2.5 EMERGENCY LIGHTING UNITS

A. Description: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

2.6 LAMPS

A. Low-Mercury Fluorescent Lamps: Comply with EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.

B. T5 Rapid-Start low-mercury Fluorescent Lamps: Rated 28W and /or 54W maximum, nominal length 48 inches, CRI 75 (minimum), color temperature 4100 K, and average rated life 20,000 hours, unless otherwise indicated.

C. Compact Fluorescent Lamps: 4-Pin, low mercury when available at specified wattage, CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at 3 hours operation per start, and suitable for use with dimming ballasts, unless otherwise indicated.

1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
6. 55 W: T4, triple tube, rated 4300 initial lumens (minimum).

D. Metal-Halide Lamps: ANSI C78.1372, with a minimum CRI 65, and color temperature 4000 K.

E. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000 K.

F. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and color temperature 4000 K.

2.7 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with other parts of the contract documents for channel- and angle-iron supports and nonmetallic channel and angle supports.
B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.


E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Comply with NFPA 70 for minimum fixture supports.

C. Suspended Lighting Fixture Support:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Adjust aimable lighting fixtures to provide required light intensities.

3.2 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 265100
SECTION 265600 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Exterior luminaries with lamps and ballasts.
2. Luminaire-mounted photoelectric relays.
3. Poles and accessories.

B. See other sections of the specifications for exterior luminaries normally mounted on exterior surfaces of buildings.

1.2 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports and supporting structure, applied as stated in AASHTO LTS-4.

B. Ice Load: Load of 3 lbf/sq. ft., applied as stated in AASHTO LTS-4.

C. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.

1. Wind speed for calculating wind load for poles exceeding 50 feet in height is 70 mph.
2. Wind speed for calculating wind load for poles 50 feet or less in height is 70 mph.

1.3 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, and finishes.

B. Shop Drawings: Include anchor-bolt templates keyed to specific poles and certified by manufacturer.

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.


C. Comply with NFPA 70.
PART 2 - PRODUCTS

2.1  MANUFACTURERS

A.  In Exterior Lighting Device Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1.  Basis of Design Product:  The design of each item of exterior luminaire and its support is based on the product named.  Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2  LUMINAIRES, GENERAL REQUIREMENTS

A.  Luminaries shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B.  Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaries.

C.  Metal Parts:  Free of burrs and sharp corners and edges.

D.  Sheet Metal Components:  Corrosion-resistant aluminum, unless otherwise indicated.  Form and support to prevent warping and sagging.

E.  Housings:  Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use.  Provide filter/breather for enclosed luminaries.

F.  Doors, Frames, and Other Internal Access:  Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools.  Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.  Doors shall be removable for cleaning or replacing lenses.  Designed to disconnect ballast when door opens.

G.  Exposed Hardware Material:  Stainless steel.

H.  Plastic Parts:  High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I.  Light Shields:  Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J.  Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:

1.  White Surfaces:  85 percent.
2.  Specular Surfaces:  83 percent.
3.  Diffusing Specular Surfaces:  75 percent.

K.  Lenses and Refractors Gaskets:  Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and tested luminaire before shipping. Where indicated, match finishes process and color of pole or support materials.


N. Factory-Applied Finish for Aluminum Luminaries: Color shall be as indicated on the drawings. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

2.3 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Provide as indicated on drawings or if no other control is indicated.

B. Comply with UL 773 or UL 773A.

C. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

   1. Relay with locking-type receptacle shall comply with NEMA C136.10.
   2. Adjustable window slide for adjusting on-off set points.

2.4 BALLASTS FOR HID LAMPS

A. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction average life. Include the following features, unless otherwise indicated:

   1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
   2. Minimum Starting Temperature: Minus 22 deg F.
   3. Normal Ambient Operating Temperature: 104 deg F.
   4. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

2.5 HID LAMPS

A. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000 K.

B. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and color temperature 4000 K.

2.6 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

A. Structural Characteristics: Comply with AASHTO LTS-4.
1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.

2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaries and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
   1. Materials: Shall not cause galvanic action at contact points.
   2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
   3. Anchor-Bolt Template: Plywood or steel.

D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified.

2.7 ALUMINUM POLES

A. Poles: As indicated on the drawings.

2.8 POLE ACCESSORIES

A. As indicated on the drawings.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

   1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaries that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources.

3.2 POLE INSTALLATION

A. Align pole foundations and poles for optimum directional alignment of luminaries and their mounting provisions on the pole.
B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:

1. Fire Hydrants and Storm Drainage Piping: 60 inches.
3. Trees: 15 feet.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements as specified in other sections of the specifications.

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use non-shrink or expanding concrete grout firmly packed to fill space.
3. Install base covers, unless otherwise indicated.
4. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top 4 inches above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in other sections of the specifications.

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Concrete materials, installation, and finishing are specified in other sections of the specifications.

3.5 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.
3.6 GROUNDING

A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole, unless otherwise indicated – extend to nearest available exterior grounding counterpoise conductor and bond by means of exothermic weld.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundations.

END OF SECTION 265600
SECTION 270000 - GENERAL PROVISIONS FOR COMMUNICATIONS

Reference Section 260000 – General Provisions for Electrical

END OF SECTION 270000
SECTION 270500 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Sleeves for pathways and cables.
   2. Sleeve seals.
   4. Common communications installation requirements.

1.2 SUBMITTALS

A. Product Data: For sleeve seals.

PART 2 - PRODUCTS

2.1 SLEEVES FOR PATHWAYS AND CABLES

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

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

   1. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
      b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.

   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Metraflex Co.
      d. Pipeline Seal and Insulator, Inc.
2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of pathway or cable.
3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR COMMUNICATIONS INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Communications penetrations occur when pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 6 inches above finished floor level.
G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and pathway or cable, unless indicated otherwise. Adjust annular clear space pending fire stop system to be used.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry.
   1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using a fire stop material that is appropriate for size, depth, and location of joint and is re-enterable allowing the capability to add and remove cabling. Comply with requirements in other specification sections.

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials. Comply with requirements in other specification sections.

K. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.

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

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

A. Furnish and install fire stopping to all penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in parts of the contract documents.
SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Telecommunications mounting elements.
   2. Backboards.
   3. Telecommunications service entrance pathways.

1.2 SUBMITTALS

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

B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies, and location and size of each field connection.
   2. Equipment racks and cabinets: Include workspace requirements and access for cable connections.

C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.
   2. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
   3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

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. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

D. Grounding: Comply with Motorola R56 Standards and Guidelines for Communications Sites.
1.4 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weather-tight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.5 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.

1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
2. Support brackets with cable tie slots for fastening cable ties to brackets.
3. Lacing bars, spools, J-hooks, and D-rings.
4. Straps and other devices.

B. Cable Trays:

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. Cable Management Solutions, Inc.
   b. Cablofil Inc.
   c. Cooper B-Line, Inc.
   d. Cope - Tyco/Allied Tube & Conduit.
   e. GS Metals Corp.
2. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch thick.
   
a. Basket Cable Trays: size as indicated on the drawings. Wire mesh spacing shall not exceed 2 by 4 inches.

C. Conduit and Boxes: Comply with requirements in "Raceway and Boxes for Electrical Systems." Flexible metal conduit shall not be used except were specifically indicated on drawings.
   
1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep or as indicated on the drawings.
2. Minimum raceway size shall be 1”.

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels.

2.3 GROUNDING

A. Comply with requirements in Division 26 Section 260526A and B for grounding conductors and connectors.

B. Sub-System Ground Busbar:
   
1. Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
2. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide with 9/32-inch holes spaced 1-1/8 inches apart.
3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

C. Comply with Motorola R56 Standards and Guidelines for Communications Sites.

2.4 LABELING

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing, when so directed by service provider.

C. Install underground entrance pathway complying with "Raceway and Boxes for Electrical Systems."

3.2 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.


D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 FIRESTOPPING

A. Comply with requirements in other sections of the specifications, maintain rating of assembly penetrated in a fashion in which cables can be added or removed without damage to cables.

B. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.4 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with Motorola R56 Standards and Guidelines for Communications Sites.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

END OF SECTION 271100
SECTION 271300 - VOICE AND DATA COMMUNICATION CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following items for wiring systems used as signal pathways for voice and high-speed data transmission:

1. Unshielded twisted-pair cabling.
2. Workstation outlets.

1.2 SUBMITTALS

A. Product Data: For each component specified.

B. Shop Drawings:

1. Include dimensioned plan and elevation views of telecommunications equipment rooms, labeling each individual component.
2. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
3. Cabling Administration Drawings.
4. Wiring diagrams to show typical wiring schematics including the following:
   a. Workstation outlets, jacks, and jack assemblies.
   b. Patch cords as applicable.
   c. Patch panels.

C. Qualification Data: For Installer.

D. Field quality-control test reports.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Cabling installer must have on staff personnel certified by BICSI.

1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of a Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Agency's Field Supervisor: Person currently certified by BICSI as an RCDD to supervise field quality-control testing.

B. Source Limitations: Obtain all products except cables through one source from a single manufacturer.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NFPA 70, "National Electrical Code."

1.4 COORDINATION

A. Coordinate layout and installation of voice and data communication cabling with Owner's telecommunications and LAN equipment and service suppliers.

   1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
   2. Record agreements reached in meetings and distribute to other participants.
   3. Adjust arrangements and locations of distribution frames and cross-connect and patch panels in equipment rooms and wiring closets to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.

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 SYSTEM REQUIREMENTS

A. Coordinate the features of materials and equipment so they form an integrated system. Match components and interconnections for optimum future performance.

B. Expansion Capability: Unless otherwise indicated, provide spare conductor pairs in cables, positions in cross-connect and patch panels, and terminal strips to accommodate 20 percent future increase in the number of workstations shown on Drawings. This expansion requirement does not apply to horizontal cable from workstation outlet to first terminal board.

2.3 MOUNTING ELEMENTS

A. Backboards: 3/4-inch, interior-grade, fire-retardant-treated plywood.
2.4 UNSHIELDED TWISTED-PAIR CABLING

A. Cable Manufacturers:

1. Avaya Inc.
2. Belden Inc.; Electronics Division.
3. CommScope Properties, LLC.
4. General Cable Technologies Corporation.
5. Helix/HiTemp Cables, Inc.
6. KRONE Incorporated.
7. Mohawk/CDT; a division of Cable Design Technologies.
9. Remee Products Corp.
10. Superior Essex; Superior Telecommunications Inc.
11. West Penn Wire/CDT; a division of Cable Design Technologies.

B. Terminal and Connector Component and Distribution Rack Manufacturers:

1. AMP; a Tyco International Ltd. Company.
2. Amphenol Corporation.
3. Avaya Inc.
5. Cooper Wiring Devices; a division of Cooper Industries, Inc.
6. Homaco.
8. KRONE Incorporated.
10. Lucent Technologies; Global Service Provider.
11. Mohawk/CDT; a division of Cable Design Technologies.
12. Molex Premise Networks; a division of Molex, Incorporated.
14. Panduit Corp.
15. Thomas & Betts Corporation.

C. 100-Ohm UTP: Comply with UL 444.

D. Backbone Copper Cable:

1. No. 24 AWG, 25 pair.
2. Comply with ICEA S-80-576 and TIA/EIA-568-B.2, Category 6A.
3. NFPA 70, type CMR complying with UL 1666.

E. Horizontal Copper Cable:

1. No. 24 AWG, 100 ohm, four pair.
2. Comply with TIA/EIA-568-B.2, Category 6A.
3. NFPA 70, types CMG.
F. Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, using modules designed for punch-down caps or tools.
   1. IDC Terminal Block Modules: Integral with connector bodies, including plugs and jacks where indicated.
   2. IDC Connecting Hardware: Consistent throughout Project.

G. Cross-Connect Panel: Modular array of IDC terminal blocks arranged to terminate building cables and permit interconnection between cables.
   1. Number of Terminals per Field: One for each conductor in assigned cables plus 25 percent spare.

H. Patch Panel: Comply with TIA/EIA-568-B.2, meeting or exceeding cable performance. Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
   1. Number of Jacks per Field: One for each four-pair UTP cable indicated. Provide 25% spare port capacity per each Communications Room.

I. Jacks and Jack Assemblies: Modular, color-coded, RJ-45 receptacle units with integral IDC-type terminals – Blue for Data and Orange for Voice. Use keyed jacks for data service.

J. Patch Cords: Furnished and installed by Owner.

2.5 WORKSTATION OUTLETS


B. Workstation Outlets: Dual jack-connector assemblies mounted in single or multi-gang faceplate.
   1. Faceplate: High-impact plastic; color as selected by Architect.
   2. Mounting: Flush, unless otherwise indicated.
   3. Legend: Machine-printed, adhesive tape label identifying the circuit.

2.6 FIBER-OPTIC CABLELING

A. Cable, Terminal, and Connector Product Manufacturers:
   1. Avaya Inc.
   2. Berk-Tek; an Alcatel Company.
   3. Chromatic Technologies; a Draka USA Company.
   4. CommScope Properties, LLC.
   5. Corning Cable Systems.
   6. General Cable Technologies Corporation.
   7. Mohawk/CDT; a division of Cable Design Technologies.
   8. Molex Premise Networks; a division of Molex, Incorporated.
10. Optical Cable Corporation.
11. Panduit Corp.
12. Prestolite Wire Corp.
13. Superior Essex; Superior Telecommunications Inc.

B. Fiber-Optic Cable: 50/125-micrometer, multimode OM3 fiber.

C. Backbone Fiber Cable: 12 fibers.

1. Comply with TIA/EIA-492AAAA, tight buffer.
2. NFPA 70, Type OFN complying with UL 1666.
3. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.25 dB/km at 1300 nm.
4. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
5. Cable Jacket Color: Orange.

D. Cross-Connect and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to satisfy specified expansion criteria.

E. Patch Cords: Furnished and installed by Owner.

F. Cable Connecting Hardware:

2. Quick-connect, couplers, per Owner’s standards. Insertion loss not more than 0.7 dB.

2.7 GROUNDING AND BONDING

A. Materials: Comply with Motorola R56, NFPA 70, TIA/EIA-607, and UL 467.

2.8 IDENTIFICATION PRODUCTS

A. Manufacturers:

1. Brady Worldwide, Inc.
2. HellermannTyton.
3. Kroy LLC.
4. Panduit Corp.

B. Comply with TIA/EIA-606-A and with applicable requirements in Division 26 Section "Electrical Identification."

C. Cable Labels: Self-adhesive vinyl or vinyl-cloth wraparound tape markers, machine printed with alphanumeric cable designations.
PART 3 - EXECUTION

3.1 INSTALLATION STANDARDS

A. Comply with BICSI TCI, TIA/EIA-568-B.1, TIA/EIA-568-B.2, TIA/EIA-568-B.3, and TIA/EIA-569-A.

3.2 EXAMINATION

A. Examine pathway elements intended for cables.
   1. Verify proposed routes of pathways. Check raceways, cable trays, and other elements for compliance with space allocations, clearances, installation tolerances, hazards to cable installation, and other conditions affecting installation. Verify that cabling can be installed complying with EMI clearance requirements.
   2. Prepare wall penetrations and verify that penetrations of rated fire walls are made using products labeled for type of wall penetrated.
   3. Identify plan to support cables and raceways in suspended ceilings. Verify weight of individual types and sizes of cables. Verify that load capacity of cable support structures is adequate for each pathway.
   4. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 APPLICATION OF MEDIA

A. Backbone Cable for Data Service: Use UTP Category 6A cable for runs between equipment rooms and wiring closets and for runs between wiring closets. Use 12 strand multi-mode fiber cable for runs between demark, equipment rooms and wiring closets and for runs between wiring closets.

B. Backbone Cable for Voice Service: Use UTP Category 6A cable for runs between equipment rooms and wiring closets and for runs between wiring closets.

C. Horizontal Cable for Data Service: Use UTP Category 6A cable for runs between wiring closets and workstation outlets.

D. Horizontal Cable for Voice Service: Use UTP Category 6A cable for runs between wiring closets and workstation outlets.

3.4 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceway and cable tray except within cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use UL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
Cable trays are specified in Division 26 Section "Communications Equipment Room Fittings." Raceways and boxes are specified in Division 26 Section "Raceways and Boxes."

C. Cable Installation:

1. Install exposed cables parallel and perpendicular to surfaces or exposed structural members and follow surface contours where possible.
2. Make splices, taps, and terminations only at indicated outlets, terminals, and cross-connect and patch panels.
3. Pulling Cable: Do not exceed manufacturer's written recommended pulling tensions. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
4. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
5. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, frames, and terminals.
6. Install UTP cables using techniques, practices, and methods that are consistent with Category 6A rating of components and that ensure Category 6A performance of completed and linked signal paths, end to end.
   a. Do not untwist more than 1/2 inch of Categories 6A cables at connector terminations.

D. Separation from EMI Sources: Comply with BICSI TDM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment. Comply with the following minimum separation distances from possible sources of EMI:

1. Separation between unshielded power lines or electrical equipment in proximity to open cables or cables in nonmetallic raceways is as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: 5 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: 12 inches.

2. Separation between unshielded power lines or electrical equipment in proximity to cables in grounded metallic raceways is as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: 2-1/2 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: 6 inches.

3. Separation between power lines and electrical equipment located in grounded metallic conduits or enclosures in proximity to cables in grounded metallic raceways is as follows:
   b. Electrical Equipment Rating between 2 and 5 kVA: 3 inches.

4. Electrical Motors and Transformers, 5 kVA or HP and Larger: 48 inches.
5. Fluorescent Fixtures: 5 inches.

E. Conduit:

1. Comply with TIA/EIA-569-A for maximum length of conduit and bends between pull points, and for pull-box sizing.
2. Use manufactured conduit sweeps and long-radius ells whenever possible.
3. In telecommunications rooms, position conduit ends adjacent to a corner on backboard (in case of a single piece of plywood) or in the corner of room (where multiple sheets of plywood are installed around perimeter walls of room). Use cable trays to route cables if conduits cannot be located in these positions. Secure conduits to backboard when entering room from overhead. Extend conduits 1 to 3 inches in finished floor.

F. Backboards: Install plywood with 48-inch dimension from floor up toward ceiling. Butt adjacent sheets tightly, and form smooth gap-free corners.

3.5 GROUNDING

A. Comply with Motorola R56, Division 26 Section 260526A and B and with TIA/EIA 607.

3.6 IDENTIFICATION

A. In addition to requirements in this Article, comply with TIA/EIA-606-A and with applicable requirements in Division 26 Section "Electrical Identification."

1. Administration class for this Project shall be Class 2.
2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Use logical and systematic designations for facility's architectural arrangement and nomenclature, and a consistent color-coded identification of individual conductors.

C. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
   a. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
   b. Label each unit and field within distribution racks and frames.
4. Within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar
jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
5. At Workstations: Attach label to device plate.

D. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

E. Cabling Administration Drawings: Show building floor plans with cable administration-point labeling. Identify labeling convention and show labels for telecommunications closets, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner 30 days prior to Occupancy.

3.7 FIELD QUALITY CONTROL

A. Perform field tests and inspections according to TIA/EIA-568-B.2 and prepare test reports.

B. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

C. Retest and inspect cabling to determine compliance of replaced or additional work with specified requirements.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets. Refer to Division 26 Section, "General Provisions for Electrical."

END OF SECTION 271300
SECTION 280000 - GENERAL PROVISIONS FOR ELECTRONIC SAFETY AND SECURITY

Reference Section 260000 – General Provisions for Electrical

END OF SECTION 280000
SECTION 280500 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Sleeves for pathways and cables.
   2. Sleeve seals.
   4. Common communications installation requirements.

1.2 SUBMITTALS

A. Product Data: For sleeve seals.

PART 2 - PRODUCTS

2.1 SLEEVES FOR PATHWAYS AND CABLES

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

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

   1. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
      b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.
2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of pathway or cable.
3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY INSTALLATION

A. Comply with NECA 1.
B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY PENETRATIONS

A. Electronic safety and security penetrations occur when raceways, pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements for "Joint Sealants."

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

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

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly.
END OF SECTION 280500
SECTION 280513 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Fire alarm wire and cable.
   2. Identification products.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. For coaxial cable, include the following installation data for each type used:
      a. Nominal OD.
      b. Minimum bending radius.
      c. Maximum pulling tension.

   B. Field quality-control reports.

   C. Maintenance data.

1.3 QUALITY ASSURANCE

A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

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.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. Support of Open Cabling: NRTL labeled for support of cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
   1. Support brackets with cable tie slots for fastening cable ties to brackets.
   2. Lacing bars, spools, J-hooks, and D-rings.
3. Straps and other devices.

B. Conduit and Boxes: Comply with requirements in "Raceway and Boxes for Electrical Systems." Flexible metal conduit shall not be used.

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches.

2.3 FIRE ALARM WIRE AND CABLE

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. Comtran Corp.
2. Draka USA.
3. Genesis Cable Products; Honeywell International, Inc.
4. Rockbestos-Suprenant Cable Corporation.
5. West Penn Wire/CDT; a division of Cable Design Technologies.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG and size as recommended by system manufacturer.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a 2-hour rating.


1. Low-Voltage Circuits: No. 16 AWG, minimum.
2. Line-Voltage Circuits: No. 12 AWG, minimum.

2.4 IDENTIFICATION PRODUCTS

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. Brady Corporation
2. HellermannTyton.
3. Kroy LLC.
4. Panduit Corp.
B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Comply with requirements of "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.

B. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

C. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems." for installation of conduits and wireways.

D. Install manufactured conduit sweeps and long-radius elbows whenever possible.

E. Pathway Installation in Equipment Rooms:
   1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
   2. Install cable trays to route cables if conduits cannot be located in these positions.
   3. Secure conduits to backboard when entering room from overhead.
   4. Extend conduits 3 inches above finished floor.
   5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

F. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.
B. General Requirements for Cabling:

1. Terminate all conductors; no cable shall contain un-terminated elements. Make terminations only at indicated outlets or terminals.
2. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, and terminals.
3. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
4. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
5. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
6. Pulling Cable: Do not exceed manufacturer's instructions as to allowable pulling tension. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

3.3 FIRE ALARM WIRING INSTALLATION

A. Comply with NECA 1 and NFPA 72.

B. Wiring Method: Install wiring in metal raceway according to "Raceway and Boxes for Electrical Systems."

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system – raceway color shall be red. This system shall not be used for any other wire or cable.

C. Wiring Method:

1. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
2. Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is not permitted.
3. Signaling Line Circuits: Power-limited fire alarm cables may be installed in the same cable or raceway as signaling line circuits.

D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with...
the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

F. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

G. Wiring to Remote Alarm Transmitting Device: 1-inch conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.4 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No. 14 AWG.
2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.5 CONNECTIONS

A. Comply with requirements in "Fire Alarm System" for connecting, terminating, and identifying wires and cables.

3.6 FIRESTOPPING

A. Comply with requirements in other specification section.

3.7 GROUNDING

A. For low-voltage wiring and cabling, comply with requirements in "Grounding and Bonding for Electrical Systems."

3.8 IDENTIFICATION

A. Comply with requirements for identification specified in "Identification for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding.
2. Visually inspect cable placement, cable termination, grounding, and bonding.

B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

C. Prepare test and inspection reports.

END OF SECTION 280513
SECTION 282310 – VIDEO DOOR INTERCOM SYSTEM

1.1 SYSTEM DESCRIPTION

A. The JM Series shall provide a large 7-inch touch screen monitor for clear visitor identification and easy operation control. The JM Series shall be installed at a maximum of 4 door locations and connected to a maximum of 8 inside locations with internal communication between stations. Connection to and integration of CCTV cameras for surveillance capabilities shall be available.

1. The system shall be hard wired and constructed with a 2-wire communication system for the door stations and a Cat5e/6 communication system for the video locations system.


B. Functional Components: As indicated on the drawings or as required to complete system.

1. Master Station.
   a. JM-4MED: Hands-free/Handset color video intercom master station.

2. Sub Master Station:
   a. JM-4HD: Hands-free/Handset color video intercom sub master station.

3. Video Door Station:
   a. JK-DVF: PanTilt & Zoom vandal-resistant video door station, flush mount.

4. Long Distance/CCTV Adaptor:
   a. JMW-BA: Long distance/CCTV adaptor.

5. Distribution Adaptor:
   a. JM-8Z: Distribution adaptor.

6. Power Supply:
   a. PS-2420UL: 24V DC Power supply.

7. Call Extension Speaker:
   a. IER-2: Call extension speaker.
8. External Devices:

   a. RY-3DL: Multiple door release adaptor.

C. System Design: Unless noted otherwise on drawings provide system layout as follows. Centralized Wiring.

   1. Provide Centralized Wiring: Connect master stations, and sub master stations to a central wiring adaptor.

      a. Maximum distance of farthest sub master from distribution adapter (JM-8Z): 165 feet (50 m).
      b. Maximum distance of master from distribution adapter (JM-8Z): 650 feet (200 m).
      c. Maximum cumulative distance of master and sub masters from distribution adapter (JM-8Z): 980 feet (300 m).

   2. Provide Expanded Performance:

      a. The wiring distance between the door and master stations by using the JMW-BA adaptor shall be a maximum distance of 980 feet (300 m).
      b. Connect CCTV and Audio Door Station: Provide security camera connection using the JMW-BA adaptor. Provide for two way communication as indicated or scheduled with a GT-D audio device.

1.2 SUBMITTALS

A. Product Data: Manufacturer's data sheets on each product to be used, including:

   1. Preparation instructions and recommendations.
   2. Storage and handling requirements and recommendations.
   3. Installation methods.

B. Shop Drawings: Submit the following:

   1. Wiring Diagrams: Indicate wiring for each item of equipment and interconnections between items of equipment.
   2. Include manufacturer's names, model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.

C. Installation and Operation Manuals:

   1. Submit manufacturer's installation and operation manual, including operation instructions and component wiring diagrams.
   2. Provide detailed information required for Owner to properly operate equipment.
D. Warranty: Submit manufacturer's standard warranty.

1.3 QUALITY ASSURANCE


B. Installer Qualifications: Factory trained and experienced with system installations of scope and size required for the Project.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturer: Aiphone Corp., which is located at: 1700 130th Ave. N. E.; Bellevue, WA 98005; Toll Free Tel: 800-692-0200; Tel: 425-455-0510; Fax: 425-455-0071; Email: request info (info@aiphone.com); Web: www.aiphone.com

B. Substitutions: Submit 10 days prior to bidding

2.2 HANDS-FREE/HANDSET COLOR VIDEO INTERCOM SYSTEM

A. Color Video Intercom System: JM Series Intercom System as manufactured by Aiphone Corporation.

B. Room Master Station: JM-4MED 7 inches Digital PTZ Video Master Station with Memory.

1. The JM Series shall accommodate up to 4 Door Stations and 8 Master Stations in a single system.

2. Provide icon driven One Touch Hands Free operation. Touch the screen to communicate with visitors using the built-in microphone and speaker or use the handset at any time during conversation for privacy.

3. Operation: From Master Station. Provide the following.

   a. Room Call: Touch screen icon to call a single sub master station or all sub master stations simultaneously.
   b. Play: Touch screen icon to play recorded images from door stations.
   c. Settings: Touch screen icon to program settings and adjustments.
   d. Security: Touch screen icon to activate the security mode or to change security settings.
   e. Monitor: Touch screen icon to monitor a door station or sub master station.
   f. Option: Touch screen icon to activate the connected external device(s).
4. Available Functions During Monitoring: Provide the following.
   a. Pan-Tilt-Zoom/Wide camera control.
   b. When monitoring is started, an image shall be shown in wide mode.
      Pan & Tilt and adjusting images shall be possible from the Master
      Station.
   c. Door release shall be possible from the Master Station.
   d. Volume control shall be possible from the Master Station.
   e. Manual recording shall be possible from the Master Station.
   f. If a CCTV camera is connected instead of a video door station at
      entrance, provide audio monitoring and communication via the GT-D.

5. Physical Characteristics:
   a. Power supply: DC 24V (from power supply).
   b. Current Consumption: 390 mA.
   c. Communication: Handset - Simultaneous communication.
   e. Ambient Temperature: 32 degree F to 104 degree F (0 to 40 degrees C).
   f. Monitor: 7 inches (180 mm) color LCD monitor.
   g. Mounting: Wall mount.
   h. Electrical box: 3-gang box.
   i. Material: Flame resistant ABS resin.
   k. Dimensions: 5-11/16 inches H x 10-1/16 inches W x 1-7/8 inches D
      (145 mm by 255 mm by 48 mm).
   l. Weight: Approx. 1.74 lbs (790 g).

C. Room Station (Sub Master Station): JM-4HD.

1. Provide icon driven One Touch Hands Free operation. Touch the screen to
   communicate using the built-in microphone and speaker or use the handset at
   any time during conversation for privacy.

2. Physical Characteristics:
   a. Power supply: DC 24V (from power supply).
   b. Current Consumption: 200 mA.
   c. Communication: Handset - Simultaneous communication.
   e. Ambient Temperature: 32 degree F to 104 degrees F (0 to 40 degrees
      C).
   f. Monitor: 7 inch color LCD monitor.
   g. Electrical box: 3-gang box.
   h. Material: Flame resistant ABS resin.
   i. Color: White.
   j. Dimensions: 5-11/16 inches H x 10-1/16 inches W x 1-7/8 inches D
      (145 mm by 255 mm by 48 mm).
k. Weight: Approx. 1.74 lbs (790 g).

D. Door/Entrance Station: JK-DA/JK-DV (JK-DVF/JK-DVF-AC)

1. The JM-4MED shall automatically record images. Recording starts approximately 2 seconds after receiving a call.
2. 170 degree wide angle and 100 degree vertical angle camera to minimize blind spots, ensuring a clear view of the door station area.
3. Zoom for Clarity/ Pantilt for Control:
   a. Video door stations feature a wide angle camera to observe more activity behind the door. In addition, digital PanTilt and Zoom can focus on an area for greater detail.
   b. Oversized buttons and intuitive icons allow for quick navigation and control. Conventional push buttons shall not be permitted.
   c. Equipped with an advanced light adjustment feature to compensate for varying light levels. If a picture is too dark, increase of the brightness level at the door station shall be controlled at the master station.

4. Record Images of Visitors:
   a. After a call is placed, the JM Series records 6 images per call to internal memory.
   b. Provide an SD / SDHC card (not included) as the primary storage location, with which recording frequency increases to 4 pictures per second for up to 10 seconds per call.
   c. Provide documentation of outside disturbances by manually recording them at any time.

5. Physical Characteristics:
   a. Operating Temperature: 14 degrees F to 140 degrees F (-10 to 60 degrees C).
   b. Dimensions:
      1) JK-DA 5-1/8 inches x 3-7/8 inches x 1-9/16 inches (131 x 99 x 40 mm).
      2) JK-DV 6-13/16 inches x 3-7/8 inches x 1 inch (173 x 98 x 25 mm).
      3) JK-DVF 8-1/4 inches x 5-5/16 inches x 7/32 inch (209 x 135 x 5.5 mm).
      4) JK-DVF back box 7-3/32 inches x 4-3/8 inches x 1-25/32 inches (180 x 110 x 45 mm).
   c. Power Supply: DC 24V (from master station).
   d. Current Consumption: 90 mA.
   e. Mounting:
1) JK-DA: Surface mount to 2x4 electrical box.
2) JK-DV: Surface mount direct to surface.
3) JK-DVF: Flush mount with included back box.

f. Weight:

1) JK-DA: 0.46 lbs (210g).
2) JK-DV: 1.3 lbs (550g).
3) JK-DVF: 1.2 lbs (550g).
4) Back Box: 0.95 lbs (430g).

E. Power Supply: PS-2420UL, 24V DC Power supply.

F. Call Extension Speaker: IER-2, Call extension speaker

G. External Devices:

1. RY-3DL: Multiple (3) door release adaptor.
2. AC-10S: Access control keypad, surface mount.
3. JK-DV + AC-10S: PanTilt & Zoom vandal-resistant video door station. Surface mounted with access control keypad.

H. Long Distance Adaptor: JMW-BA

1. Power Supply: DC 24V (from power supply)
2. Current Consumption: 90 mA
3. Operating Temperature: 32 degree F to 104 degrees F (0 to 40 degrees C).
4. Mounting: Wall-mount
5. Weight: Approx. 7 oz (200 g).

I. Distribution Adaptor: JM-8Z.

1. Power Supply: DC 24V (from power supply)
2. Current Consumption: 90 mA
3. Operating Temperature: 32 degree F to 104 degrees F (0 to 40 degrees C).
5. Weight: Approx. 7.5 oz (210 g).

PART 3 EXECUTION

3.1 PREPARATION

A. Verify the following compliance before starting installation.

1. All units, except for the entrance station and tenant door station, are designed for indoor use only. Do not use outdoors.
2. The unit turns inoperative during power failure.
3. In areas where broadcasting station antennas are close by, intercom system may be affected by radio frequency interference.

4. Keep the intercom wires at least 1 foot (30 cm) away from strong electrical wiring (AC 100-240 V) including, in particular, wiring for inverter electrical appliances. Noise and malfunction could result.

5. Keep the unit more than 3.3 feet (1 m) away from radio or TV set.

6. If a strong light shines on the main unit screen, the picture may turn white or only silhouettes will be visible.

7. Other manufacturer's devices (such as sensor, detectors, door releases) used with this system, comply with the manufacturer's installation requirements.

8. The LCD panel is manufactured with very high precision techniques, inevitably will have a very small portion of its picture elements always lit or not lit at all. This is not considered a unit malfunction. Please be aware of this in advance.

3.2 INSTALLATION

A. Install integrated security and communication system in accordance with manufacturer's instructions at locations indicated on the Drawings.

B. Mount equipment plumb, level, square, and secure. For video entrance stations and video door stations, comply with manufacturer's design requirements to provide optimum picture quality of station monitoring.

3.3 SET-UP AND ADJUSTING

A. Adjust integrated security and communication system for proper operation in accordance with manufacturer's instructions.

3.4 DEMONSTRATION AND TRAINING

A. Demonstration:

1. Demonstrate that integrated security and communication system functions properly.

2. Perform demonstration at final system inspection by qualified representative of manufacturer.

B. Instruction and Training:

1. Provide instruction and training of Owner's personnel as required for operation of integrated security and communication system.

2. Provide hands-on demonstration of operation of system components and complete system, including user-level program changes and functions.

3. Provide instruction and training by qualified representative of manufacturer.
3.5 PROTECTION

A. Protect installed integrated security and communication system from damage during construction.

END OF SECTION 282310
SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Fire-alarm control unit.
   3. System smoke detectors.
   5. Magnetic door holders.
   7. Digital alarm communicator transmitter.
   8. BACnet gateway hardware and software.
   9. Supervision of dry chemical suppression systems (Kitchen and Network rooms).

1.2 SYSTEM DESCRIPTION

A. Analog/addressable multiprocessor-based fire alarm control panel. This panel shall include system cabinet, basic system module, associated peripheral devices, programming, wiring and other relevant components.

1.3 SUBMITTALS

A. General Submittal Requirements:
   1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
   2. Shop Drawings shall be prepared by persons with the following qualifications:
      a. Trained and certified by manufacturer in fire-alarm system design.
      b. NICET-certified fire-alarm technician, Level III minimum.

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

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

   2. Include voltage drop calculations for notification appliance circuits.
   3. Include battery-size calculations.
   4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.

6. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

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

1. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.

2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.

E. Qualification Data: For qualified Installer.

F. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

G. Field quality-control reports.

H. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.

3. Record copy of site-specific software.

4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:

   a. Frequency of testing of installed components.

   b. Frequency of inspection of installed components.

   c. Requirements and recommendations related to results of maintenance.

   d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.

6. Abbreviated operating instructions for mounting at fire-alarm control unit.

7. Copy of NFPA 25.

I. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.

2. Program Software Backup: On magnetic media or compact disk, complete with data files.

3. Device address list.
4. Printout of software application and graphic screens.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

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

PART 2 - GENERAL PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product name or designation or comparable product by one of the following:
   1. Faraday; Siemens Building Technologies, Inc.
   3. Fire Control Instruments, Inc.; a Honeywell company.
   4. Fire Lite Alarms; a Honeywell company.
   5. Gamewell; a Honeywell company.
   6. GE Vigilant; a unit of General Electric Company.
   8. NOTIFIER; a Honeywell company.
   10. Fike Fire Alarm Systems

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices:
   2. Heat detectors.
   3. Smoke detectors.
   4. Duct smoke detectors.
   5. Automatic sprinkler system water flow.

B. Fire-alarm signal shall initiate the following actions:
2. Identify alarm at the fire-alarm control unit and remote annunciator.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
7. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Low-air-pressure switch of a dry-pipe sprinkler system.
3. Kitchen range hood suppression system(s).
4. Dry chemical suppression system(s).

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control unit.
4. Ground or a single break in fire-alarm control unit internal circuits.
5. Abnormal ac voltage at fire-alarm control unit.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.
9. Fire-pump power failure, including a dead-phase or phase-reversal condition.
10. Low-air-pressure switch operation on a dry-pipe or pre-action sprinkler system.

E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
   a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
   b. Include a real-time clock for time annotation of events on the event recorder and printer.
2. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: Liquid-crystal type, 3 lines of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

C. Circuits:

1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
   a. Notification Appliance Circuits: Style Z.
   c. Install no more than 50 addressable devices on each signaling line circuit.

2. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class B.
   a. Notification Appliance Circuits: Style Y.
   c. Install no more than 50 addressable devices on each signaling line circuit.

D. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be connected to fire-alarm system.

E. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

F. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals and supervisory signals shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

G. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.


H. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

I. BACnet IP gateway hardware/software shall communicate information gathered by control panel and provide address and status of devices and system to other building management systems.

2.4 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show
visible indication of operation; and shall be mounted on recessed outlet box. If indicated as
surface mounted, provide manufacturer's surface back box.
1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with
   integral addressable module arranged to communicate manual-station status (normal,
   alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to
   permit lifting for access to initiate an alarm. Lifting the cover actuates an integral
   battery-powered audible horn intended to discourage false-alarm operation.
4. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the
top to permit lifting for access to initiate an alarm.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:
   1. Comply with UL 268; operating at 24-V dc, nominal.
   2. Detectors shall be two-wire type.
   3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm,
      or trouble) to fire-alarm control unit.
   4. Base Mounting: Detector and associated electronic components shall be mounted in a
      twist-lock module that connects to a fixed base. Provide terminals in the fixed base for
      connection to building wiring.
   5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to
      restore them to normal operation.
   6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-
      on status.

B. Photoelectric Smoke Detectors:
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to
      identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to
      manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to
      identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to
      manually access the following for each detector:
      a. Primary status.
      b. Device type.
c. Present average value.
d. Present sensitivity selected.
e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

D. Single-Station Duct Smoke Detectors:

1. Comply with UL 268A; operating at 120-V ac.
2. Sensor: LED or infrared light source with matching silicon-cell receiver.
   a. Detector Sensitivity: Smoke obscuration between 2.5 and 3.5 percent/foot when tested according to UL 268A.
3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.
   a. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
5. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.6 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

B. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.

C. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

D. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.
E. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.

1. Rated Light Output:
   a. 15/30/75/110/177 cd as required
   b. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.

2.7 MAGNETIC DOOR HOLDERS
A. Description: Units are equipped for wall or floor mounting as indicated by the architect and are complete with matching doorplate.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.8 REMOTE ANNUNCIATOR
A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Surface cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.9 DIGITAL ALARM COMMUNICATOR TRANSMITTER
A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone lines and dial a preset number for a remote central station. When contact is made with central station, signals shall be transmitted.
If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:
   1. Verification that both telephone lines are available.
   2. Programming device.
   3. LED display.
   5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:
   1. Address of the alarm-initiating device.
   2. Address of the supervisory signal.
   3. Address of the trouble-initiating device.
   4. Loss of ac supply or loss of power.
   5. Low battery.
   6. Abnormal test signal.
   7. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - GENERAL EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches above the finished floor.
   1. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
   2. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Smoke- or Heat-Detector Spacing:
   2. Smooth ceiling spacing shall not exceed 30 feet.
3. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A in NFPA 72.

4. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return-air opening.

5. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

D. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

E. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

F. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

G. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling.

H. Device Location-Indicating Lights: Locate in public space near the device they monitor.

I. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches above the finished floor.

J. Annunciator: Install with top of panel not more than 72 inches above the finished floor.

3.2 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
2. Alarm-initiating connection to elevator recall system and components.
3. Alarm-initiating connection to activate emergency lighting control.
4. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
5. Supervisory connections at valve supervisory switches, including switches in valve boxes exterior to the building.
6. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

C. All pull and junction boxes shall have red covers.

3.4 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

3.5 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Tests and Inspections:
   1. Visual Inspection: Conduct visual inspection prior to testing.
      a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
      b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
   3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
   4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
   5. Test visible appliances for the public operating mode according to manufacturer's written instructions.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.
E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

H. For a period of one year after final acceptance of the system by the A.H.J. and engineer provide remote station monitoring by a U.L. listed remote supervisory.

END OF SECTION 283111