

**SECTION 23 0005  
BASIC HVAC REQUIREMENTS**

**PART 1 GENERAL**

**1.01 RELATED DOCUMENTS**

- A. This section applies to all sections of Division 23.
- B. Drawings and general provisions of the contract, including Division 00 and Division 01 specification sections, apply to work of this section.
- C. Provide all items, articles, materials, operations or methods listed, mentioned or scheduled on drawings and/or herein, including all labor, materials, equipment and incidentals necessary and required for their completion.
- D. The items in this section are supplementary to the requirements set forth in other portions of the specifications as indicated under item "A" above.

**1.02 APPLICATION**

- A. This section applies to all mechanical work. The contractors involved shall check all sections of the specifications in addition to the particular section covering their specific trade. Each distinct section of the specifications aimed for one trade may have detailed information with regards to other trades, therefore, it is imperative that all sections be reviewed to get a complete picture of all other trades' functions and work required.
- B. The mechanical contractor is responsible for the installation and operation of the hvac systems and temperature control systems.
- C. The mechanical contractor is responsible for receiving, unloading and placement of all of the owner provided equipment.

**1.03 INSPECTION OF SITE**

- A. Visit the site, examine and verify the conditions under which the work must be conducted before submitting proposal.
- B. The submitting of a proposal implies that the contractor has visited the site and understands the conditions under which the work must be conducted.

**1.04 ALTERNATES AND SUBSTITUTIONS**

- A. Refer to Division 01 - General Requirements for procedures.

**1.05 DEVIATION FROM BASIS OF DESIGN MANUFACTURER**

- A. Products identified within the schedules and details are used as the basis of design for laying out and coordinating with other trades such as structural, architectural, and electrical. Should the Division 23 Contractors submit equipment by a Manufacturer other than that indicated as the Basis of Design in the Drawings, Contractor shall then be responsible for evaluating the impacts of the proposed Manufacturer's equipment, even if the Manufacturer is listed in the specifications as an approved equal. This includes the proposed Manufacturer's electrical, architectural and structural requirements and their subsequent impacts on the current design (roof openings, curbs, structural support, etc.) and coordination of any differing dimensions and clearances with all other trades.

**1.06 MATERIALS**

- A. Mechanical equipment is to be furnished with motors, electrical controls and protective devices, and integral operating devices which are normally included by the manufacturer or required by the Contract Documents.
- B. The Mechanical Trades shall provide all control wiring, 120 volts and less, for the equipment and devices furnished under Division 22, and 23 of these specifications, including all wiring devices, conduit, etc.
- C. Power wiring 120 volts and greater shall be by the Electrical Trades.

**1.07 DRAWINGS**

- A. The drawings are diagrammatic and show the general location and arrangement of all equipment, piping and related items. They shall be followed as closely as elements of the construction will permit.
- B. Examine the drawings of other trades and verify the conditions governing the work on the job site. The mechanical and electrical contractor shall check all documents including architectural, structural, plumbing, HVAC and electrical to avert possible installation conflicts. Arrange work accordingly, providing such fittings, traps, valves and accessories as may be required to meet such conditions.
- C. Deviations from the drawings, with the exception of minor changes in routing and other such incidental changes that do not affect the functioning or serviceability of the systems, shall not be made without the written approval of the Architect/Engineer.
- D. The architectural and structural drawings take precedence in all matters pertaining to the building structure, mechanical drawings in all matters pertaining to mechanical trades and electrical drawings in all matters pertaining to electrical trades. Where there are conflicts or differences between the drawings for the various trades, report such conflicts or differences to the Architect/Engineer for resolution.
- E. Do not scale drawings for measurements.
- F. Field verifications of actual existing conditions are required by the contractor since actual locations, distances, and levels will be governed by actual field conditions. All measurements shall be verified at the site.
- G. If during field verification, the contractor identifies that there may require substantial changes from the original plans, the contractor shall notify the architect for agreement on necessary adjustment before the installation is started
- H. Discrepancies shown between plans, or between plans and actual field conditions, or between plans and specifications shall promptly be brought to the attention of the Architect/Engineer for a decision.
- I. Drawings and specifications are intended to cover the completed installation of systems to function as described. The omission of the expressed reference to any item of labor and material necessary to comply with practice codes, ordinances, etc., shall not relieve the contractor from providing such additional labor and material at no cost to Owner.

#### **1.08 CODES, PERMITS AND FEES**

- A. Unless otherwise indicated, all required permits, licenses, inspections, approvals and fees for mechanical work shall be secured and paid for by the contractor. All work shall conform to all applicable codes, rules and regulations. Applicable publications listed in all sections of Division 23 shall be the latest issue, unless otherwise noted.
- B. Rules of local utility companies and municipalities shall be complied with. Check with the utility company and/or municipality supplying service to the installation and determine all devices including, but not limited to: meters, regulators, valves which will be required and include the cost of all such items in the proposal.
- C. All work shall be executed in accordance with the rules and regulations set forth in local and state codes. Prepare any detailed drawings or diagrams which may be required by the governing authorities. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern.

#### **1.09 MAINTENANCE**

- A. Provide 40 hours of instruction to the owner's designated personnel in the maintenance and operation of equipment and systems.

- B. Provide complete maintenance and operating instructional manuals covering all mechanical equipment herein specified, together with parts lists. Maintenance and operating instructional manuals shall be job specific to this project. Generic manuals are not acceptable. Four (4) copies of all literature shall be furnished for owner and shall be bound in book or ring binder form. Maintenance and operating instructional manuals shall be provided when construction is approximately 75% complete.

#### **1.10 WARRANTY AND GUARANTEE**

- A. Contractor shall guarantee all work installed by themselves or their subcontractors to be free from defect in material and workmanship for a period of one year from date of final acceptance of the work, unless a longer period is stipulated under specific headings. Contractor shall repair or replace at no additional cost to the owner, any material or equipment developing defects and shall also make good any damage caused by such defects or the correction of defects. Repairs or replacements shall bear additional guarantee, as originally called for, dated from the final acceptance of the repair or replacement. This requirement shall be binding even though it will exceed product guarantees normally furnished by some manufacturers. Contractor shall submit his own and each equipment manufacturers written certificates, warranting that each item of equipment furnished complies with all requirements of the drawings and specifications. Note that guarantee shall run from date of final acceptance of the work, not from date of installation of a device or piece of equipment.

#### **1.11 SUBMITTALS**

- A. Refer to Division 01 - General Requirements for procedures.
- B. Contractor shall provide submittals where items are referred to by symbolic designation on the drawings. All submittals shall bear the same designation (hvac equipment, piping equipment, etc.). Refer to other sections of the mechanical specifications for additional requirements.
- C. Engineer WILL NOT REVIEW:
  - 1. Submittals not specified.
  - 2. Submittals not reviewed by Contractor, including Contractor stamp with signature comments.
  - 3. Submittals made after work is delivered to site and/or installed.
  - 4. Submittal resubmissions unless resubmission is required by Architect/Engineer.
- D. Types of submittals include the following:
  - 1. Shop Drawings
  - 2. Product Data Sheets
  - 3. Samples
  - 4. Manufacturers Instructions
  - 5. Maintenance Data
  - 6. Warranty
- E. Installation of any item that requires submittal approval by the engineer shall be installed at the contractors risk. The contractor, at his cost, shall remove all work installed prior to approval of the submittal.
- F. The engineer will not be responsible for errors in quantities, or dimensions required to fit the job condition, details of fabrication to insure proper assembly at the job, or for errors resulting from mistakes in submittals.

#### **1.12 RECORD DRAWINGS**

- A. Refer to Division 01 - General Requirements for procedures.
- B. Contractor shall provide the following record drawings as part of the Project closeout document process:
  - 1. Contract Documents, specifications and submittals, indicating "As-Built" conditions and actual products selected for use.
  - 2. Product and Maintenance manuals for all equipment listed within this specification manual and in Contract Documents. Provide with parts lists as applicable.

- C. Record drawings shall be maintained by the contractor up to date as the project progresses.
- D. Recording all deviations from the contract documents, indicate exact locations of all buried services both inside and outside of the building; include concealed piping and equipment in the entire contract. Final record drawings shall reflect the as-built conditions.

### **1.13 QUALITY ASSURANCE**

- A. Other referenced standards:
  - 1. Comply with referenced standards, guidelines, data sheets from various associations, including NFPA, ANSI, ASTM, ASME, ASHRAE

## **PART 2 PRODUCTS**

### **2.01 SLEEVES AND ESCUTCHEONS**

- A. Provide sleeves wherever pipes pass through exterior wall, and floors. Sleeves shall be schedule 40 steel pipe cut to length. Sleeves shall terminate flush with walls, partitions and ceilings in finished areas. All sleeves through floor shall extend 2" above floor. Provide cast brass nickel-plated escutcheons with positive catches on each visible sleeve penetration. Sleeves are to be sealed at each installation with a 3M approved sealant. The space between the inside of the sleeve and the outside of the pipe or conduit within the sleeve shall be sealed at each installation with a 3M approved sealant.

### **2.02 DIELECTRIC UNIONS**

- A. Dielectric unions shall be used to connect dissimilar metals (such as steel and copper) to prevent electrolytic action.

### **2.03 FILTERS**

- A. Provide and maintain filters in air handling systems throughout the construction period and prior to final acceptance of the building. Do not run air handling equipment without all prefilters and final filters as specified. Immediately prior to final building acceptance by the owner, contractor shall replace all disposable type air filters with new.

### **2.04 BUILDING ATTACHMENTS FOR MECHANICAL WORK SUPPORTS**

- A. General Requirements:
  - 1. Provide building attachments required for supporting mechanical work, suitably selected and installed for the loads applied with a minimum additional safety factor of 3.
  - 2. Where specified attachments are not suitable for conditions, submit to Engineer for approval, proposal for alternate building attachments.
  - 3. If specially designed building attachments are required, retain the services of a licensed structural engineer to design such building attachments.
  - 4. Approved Manufacturers: Grinnell, or equivalent products by Michigan Hanger and B-Line.
  - 5. Provide supplemental trapeze supports where necessary. Design trapeze to support all trades. Coordinate loads, and supports with all trades. Size trapeze for maximum deflection of 1/64 of the span.
- B. Attachments to Structural Steel:
  - 1. Support mechanical work from building structural steel where possible and approved. No welding or bolting to structural steel is permitted unless authorized by Architect. C-clamps are not permitted.
    - a. Center beam clamp - for loads over 120 lb.: Malleable center hung Grinnell Fig. 228.
    - b. Side beam clamp with retaining clips - for loads up to 120 lb.
- C. Cast in Place Concrete Inserts:
  - 1. Provide inserts selected for applied load of present load plus 100% for future, and coordinated with concrete work. Except as detailed on drawings, inserts shall be Unistrut or Grinnell. Plan, lay out and coordinate setting of inserts prior to concrete pour. Use Grinnell Fig. 285 lightweight concrete insert for loads up to 400# or Grinnell Fig. 281 Wedge Type concrete insert for loads up to 1200#
- D. Drilled Insert Anchors:

1. Where mechanical work cannot be supported from structural steel, or cast in place concrete inserts, provide drilled concrete insert anchors. Submit for approval, project specific installation drawings for all loads over 100 lbs. Install inserts in web of beam if possible and approved. Insert depth shall not exceed two thirds the thickness of the concrete. Where existing concrete appears to be deteriorating, or where applied load at insert exceeds 1000 lbs., conduct test of concrete to determine derated capacity of insert. Anchors may be adhesive or expansion type up to 1000 lbs., and shall be adhesive type for loads over 1000 lbs.
2. Manufacturers: Hilti

## **PART 3 EXECUTION**

### **3.01 GENERAL**

- A. Existing piping and ductwork: when encountered during the course of work, protect, brace and support existing piping and ductwork where required for proper execution of the work.
- B. Interruption of existing active piping and ductwork: when the course of work makes shut-down of services unavoidable, the mechanical contractor shall schedule the shut-down at such time as approved by the owners representative, which will cause least interference with established operating routine.
- C. Arrange work accordingly, providing such fittings as duct transitions traps, valves and accessories necessary to complete all construction in an orderly fashion.
- D. Install all equipment in strict accordance all directions and recommendations furnished by the manufacturer.
- E. Roof mounted equipment requiring service shall be located a minimum of 10 feet from roof edges. Where equipment can't be located away from roof edge and guard rails are not provided, provide permanent fall arrest anchorage connection device that complies with ANSI/ASSE Z 359.1.

### **3.02 ACCESSIBILITY**

- A. Do not locate valves, traps, controls, unions, dampers, etc. in any system at a location that will be inaccessible after construction is completed. Maintain accessibility for all components in mechanical, electrical, and plumbing systems.

### **3.03 ACCESS DOORS AND PANELS**

- A. Refer to Division 08 - Openings; Provide access doors in locations as required by applicable codes and as indicated below. Coordinate locations with architectural trades.
- B. Furnish access panels to access valves, traps, control valves or devices, dampers, damper motors, etc. Access panels shall be sized as necessary for ample access, or as indicated on drawings, but no smaller than 12" x 12" where devices are within easy reach of operator, and at least 24"x24" when operator must pass through opening in order to reach the devices. Architectural Trades shall install access panels coordinated with Mechanical Trades.
- C. Access panels in fire rated walls or ceiling must be U.L. labeled for intended use. Unless otherwise indicated on plans, access doors shall be hinged flush type steel framed panel, 14 gauge minimum for frame, and with anchor straps. Only narrow border shall be exposed. Hinges shall be concealed type. Locking device shall be flush type and screw driver operated. Metal surfaces shall be prime coated with rust-inhibitive paint. Panels shall be compatible with architectural adjacent materials Manufacturer: Milcor, Bilco.

### **3.04 CUTTING AND PATCHING**

- A. Refer to Division 01 - General Requirements and Division 02 - Existing Conditions.
- B. All cutting required shall be done by the contractor whose work is involved, without extra cost the owner. All patching and restoration including the furnishing and installation of access panels in ceiling, walls; etc. Within the building lines shall be done by the respective, responsible contractor. No cutting of structural steel, concrete, or wood shall be done without prior approval and explicit directions of the architect patched by the respective, responsible contractor.

- C. The contractor, under whose jurisdiction the work may fall, shall provide labor, material, and tools required to cut, repair, protect, cap, or relocate existing pipes, conduits, or utilities interfering with or uncovered during work, per regulations of the authorities having jurisdiction.

### **3.05 ROUGH-IN FOR CONNECTION TO EQUIPMENT**

- A. It shall be the responsibility of each contractor to study the architectural, structural, electrical, and mechanical drawings, conferring with the various trades involved and checking with the supplier of equipment in order to properly rough-in for all equipment.

### **3.06 MATERIAL AND EQUIPMENT**

- A. All material and equipment shall be new and of the best quality used for the purpose in good commercial practice, and shall be the standard product of reputable manufacturers. The material and equipment must meet approval of state and local codes in the area it is being used. Roof decks shall not be used to support piping, conduit, equipment, devices, etc.

### **3.07 SEAL PENETRATIONS**

- A. Seal the space around pipes in sleeves and around duct openings through walls, floors and ceilings. Provide adequate clearance to allow for proper sealing.

### **3.08 SOUND CONTROL**

- A. Penetrations shall be maintained airtight to prevent sound transfer.
- B. Piping, ductwork, etc. shall pass through sleeves. Pack sleeves tight with glass fiber or oakum and caulked on both sides with non-hardening acoustical sealant.

### **3.09 FIRESTOPPING**

- A. Refer to Division 07 - Thermal and Moisture Protection for more information.
- B. Provide UL classified firestopping system for mechanical penetrations through rated walls and floors to maintain the fire rating.

### **3.10 DELIVERY, STORAGE AND HANDLING OF EQUIPMENT AND MATERIALS**

- A. Refer to Division 01 - General Requirements; All equipment and materials shall be delivered, stored and secured per manufacturer's recommendations.
- B. On-site storage shall be coordinated with Construction Manager and be performed in a manner as to avoid damage, deterioration and loss.
- C. Contractor shall provide temporary protection for installed equipment prior to project completion.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. All equipment shall be inspected prior to installation to assure that equipment is free from defect and damage.
- F. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.
- G. Protect dampers, grilles, louvers from damage to operating linkages and blades.

### **3.11 CLEANING**

- A. Refer to Division 01 - General Requirements; all mechanical equipment and components shall be cleaned as frequently as necessary through the construction process and again prior to project completion.

### **3.12 CONTROL WIRING**

- A. All control wiring for mechanical and electrical equipment, including motor starters, shall be 120 volt maximum and wired with one side of the coil grounded and the operating contacts in the north side of the circuit. All control wiring shall be installed in conduit.

**END OF SECTION**

**SECTION 23 0505  
SELECTIVE DEMOLITION FOR HVAC**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Demolition and extension of existing mechanical work.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements.
- B. Division 02 - Existing Conditions: Demolition, cleaning and disposal requirements, cutting and patching requirements, repairs.

**1.03 SUMMARY**

- A. The work covered under this section consists of the furnishing of all necessary labor, supervision, materials, equipment, and services to completely execute the system of minor electrical demolition as described in this specification.
- B. The demolition documents plans and specification have been prepared from existing non-as built documents and cursory non-invasive field investigation.
- C. It is the contractors obligation to become familiar with the extent of demolition and the existing condition before submitting their bid.
- D. During demolition if the contractor discovers unforeseen significant non-code compliance conditions of the existing installation they shall notify the Architect and Engineer immediately in writing.
- E. The contractor shall become familiar with the drawings and scope of work of other trades as the work scope of those trades relates to mechanical equipment and connection requirements.
- F. During demolition the contractor shall record on site as-builts all hydronic system piping capped branches, capped supply air, return air and exhaust ducts for reuse in renovated project space.

**PART 2 PRODUCTS**

**2.01 MATERIALS**

- A. Materials and equipment for patching and extending work: As specified in individual sections.

**PART 3 EXECUTION**

**3.01 EXAMINATION**

- A. Verify that piping, ductwork, equipment, accessories, controls and control wiring/tubing to be demolished serve only equipment and facilities within the demolition areas.
- B. Demolition drawings are based on casual field observation and existing record documents.
- C. Report discrepancies between drawings and field conditions to Owner and Engineer before disturbing existing installation.
- D. Beginning of demolition means installer accepts existing conditions.

**3.02 PREPARATION**

- A. Identify locations for capping piping, ductwork and controls before any demolition work commences.
- B. Confirm isolation valve locations for hydronic piping. Repair leaking isolation valves or replace inoperable valves before commencing piping demolition.
- C. Cap and seal air-tight supply, return and exhaust air ductwork at shaft walls before commencing sheet metal demolition.
- D. Identify existing controls wiring and/or tubing that serves equipment before any demolition work commences.

**3.03 DEMOLITION AND EXTENSION OF EXISTING MECHANICAL WORK**

- A. Remove, relocate, and extend existing mechanical piping, sheet metal, and controls work to accommodate new construction.
- B. Remove hydronic water piping back to isolation valve.
- C. Remove all supply, return and exhaust air ductwork back to main connection.
- D. Contractor shall ensure all modified systems are functional and in working order.
- E. Pneumatic tubing for demolished equipment shall be removed back to mains and mains capped. Where existing pneumatic control systems are partially demolished or modified, the contractor shall take extra care to ensure that portions of the existing system intended to remain are left in proper working order.

**3.04 CLEANING AND REPAIR**

- A. Refer to Division 01 - General Requirements for procedures.
- B. Clean and repair existing materials, piping, sheet metal, diffusers, accessories and equipment that remain or that are to be reused.

**END OF SECTION**



**SECTION 23 0519  
METERS AND GAUGES FOR HVAC PIPING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Pressure gauges and pressure gauge taps.
- B. Thermometers and thermometer wells.

**1.02 RELATED REQUIREMENTS**

- A. Section 23 2113 - Hydronic Piping.

**1.03 REFERENCE STANDARDS**

- A. ASME B40.100 - Pressure Gauges and Gauge Attachments; 2022.
- B. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers; 2014 (Reapproved 2020).
- C. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers; 2014 (Reapproved 2021).
- D. UL 393 - Indicating Pressure Gauges for Fire-Protection Service; Current Edition, Including All Revisions.

**1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide list that indicates use, operating range, total range and location for manufactured components.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  - 1. See Section 01 6000 - Product Requirements, for additional provisions.
  - 2. Extra Pressure Gauges: One of each type and size.

**1.05 FIELD CONDITIONS**

- A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

**PART 2 PRODUCTS**

**2.01 PRESSURE GAUGES**

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: [www.dwyer-inst.com/#sle](http://www.dwyer-inst.com/#sle).
  - 2. Moeller Instrument Company, Inc: [www.moellerinstrument.com/#sle](http://www.moellerinstrument.com/#sle).
  - 3. Omega Engineering, Inc: [www.omega.com/#sle](http://www.omega.com/#sle).
  - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Pressure Gauges: ASME B40.100, UL 393 drawn steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
  - 1. Case: Steel with brass bourdon tube.
  - 2. Size: 4-1/2 inch diameter.
  - 3. Mid-Scale Accuracy: One percent.
  - 4. Scale: Psi and KPa.

**2.02 PRESSURE GAUGE TAPPINGS**

- A. Gauge Cock: Tee or lever handle, brass for maximum 150 psi.
- B. Needle Valve: Brass, 1/4 inch NPT for minimum 150 psi.

**2.03 STEM TYPE THERMOMETERS**

- A. Manufacturers:
  - 1. Dwyer Instruments, Inc: [www.dwyer-inst.com/#sle](http://www.dwyer-inst.com/#sle).

2. Omega Engineering, Inc: [www.omega.com/#sle](http://www.omega.com/#sle).
  3. Weksler Glass Thermometer Corp: [www.wekslerglass.com/#sle](http://www.wekslerglass.com/#sle).
  4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Thermometers - Adjustable Angle: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device; adjustable 360 degrees in horizontal plane, 180 degrees in vertical plane.
1. Size: 9 inch scale.
  2. Window: Clear Lexan.
  3. Stem: 3/4 inch NPT brass.
  4. Accuracy: 2 percent, per ASTM E77.
  5. Calibration: Degrees F.

#### **2.04 TEST PLUGS**

- A. Test Plug: 1/4 inch or 1/2 inch brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with neoprene core for temperatures up to 200 degrees F.

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Provide one pressure gauge per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gauge.
- C. Install pressure gauges with pulsation dampers. Provide gauge cock to isolate each gauge. Extend nipples to allow clearance from insulation.
- D. Provide instruments with scale ranges selected according to service with largest appropriate scale.
- E. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- F. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- G. Locate test plugs where indicated; coordinate with Temperature Controls Contractor and Test and Balance Contractor for any additional locations needed to complete their work.

#### **3.02 SCHEDULE**

- A. Pressure Gauges, Location:
  1. Pumps.
  2. Expansion tanks.
  3. Bypass/side-stream filters.
- B. Pressure Gauge Tappings, Location:
  1. Control valves 3/4 inch & larger - inlets and outlets.
  2. Major coils - inlets and outlets.
  3. Boiler - inlets and outlets.
- C. Stem Type Thermometers, Location:
  1. Headers to central equipment.
  2. Boilers - inlets and outlets.
  3. As noted on plans, diagrams and details.

**END OF SECTION**

**SECTION 23 0523  
GENERAL-DUTY VALVES FOR HVAC PIPING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Ball valves.
- B. Butterfly valves.
- C. Check valves.
- D. Combination flow measuring and balancing valves.

**1.02 RELATED REQUIREMENTS**

- A. Section 23 0553 - Identification for HVAC Piping and Equipment.
- B. Section 23 0719 - HVAC Piping Insulation.
- C. Section 23 2113 - Hydronic Piping.

**1.03 ABBREVIATIONS AND ACRONYMS**

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. PTFE: Polytetrafluoroethylene.
- E. TFE: Tetrafluoroethylene.
- F. WOG: Water, oil, and gas.

**1.04 REFERENCE STANDARDS**

- A. API STD 594 - Check Valves: Flanged, Lug, Wafer, and Butt-Welding; 2022.
- B. ASME B1.20.1 - Pipe Threads, General Purpose, Inch; 2013 (Reaffirmed 2018).
- C. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250; 2020.
- D. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard; 2020.
- E. ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves; 2022.
- F. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2021.
- G. ASME B16.34 - Valves — Flanged, Threaded, and Welding End; 2020.
- H. ASME B31.9 - Building Services Piping; 2020.
- I. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings; 2004 (Reapproved 2023).
- J. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures; 1999 (Reapproved 2022).
- K. ASTM A536 - Standard Specification for Ductile Iron Castings; 1984, with Editorial Revision (2019).
- L. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings; 2017.
- M. AWWA C606 - Grooved and Shouldered Joints; 2022.
- N. MSS SP-45 - Drain and Bypass Connections; 2020.
- O. MSS SP-67 - Butterfly Valves; 2022.
- P. MSS SP-71 - Gray Iron Swing Check Valves, Flanged and Threaded Ends; 2018.
- Q. MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves; 2019.
- R. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends; 2010, with Errata .

## 1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.

## 1.06 QUALITY ASSURANCE

- A. Manufacturer:
  - 1. Obtain valves for each valve type from single manufacturer.

## PART 2 PRODUCTS

### 2.01 APPLICATIONS

- A. Listed pipe sizes shown using nominal pipe sizes (NPS) and nominal diameter (DN).
- B. Provide the following valves for the applications if not indicated on drawings:
  - 1. Throttling (Hydronic): Combination Flow Measuring and Balancing.
  - 2. Isolation (Shutoff): Butterfly and Ball.
  - 3. Pump Outlet: Spring Loaded Check.
  - 4. Dead-End: Butterfly, single-flange (lug) type.
  - 5. Drain Valve: Ball with hose end connection and cap.
- C. Substitutions of valves with higher CWP classes or WSP ratings for same valve types are permitted when specified CWP ratings or WSP classes are not available.
- D. Required Valve End Connections for Non-Wafer Types: Use flanges, unions or grooved couplings to allow disconnection of components for servicing.
- E. Hydronic Valves:
  - 1. 2 NPS and Smaller, Bronze or Hot Forged Brass Valves.
  - 2. 2-1/2 NPS and Larger, Cast Steel Valves or Butterfly Valves.

### 2.02 GENERAL REQUIREMENTS

- A. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.
- B. Valve Sizes: Match upstream piping unless otherwise indicated.
- C. Valve Actuator Types:
  - 1. Gear Actuator: Quarter-turn valves 8 inch and larger.
  - 2. Handwheel: Valves other than quarter-turn types.
  - 3. Hand Lever: Quarter-turn valves 6 NPS and smaller.
- D. Valves in Insulated Piping: Provide 2 inch stem extensions and the following features:
  - 1. Ball Valves: Extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
  - 2. Butterfly Valves: Extended neck.
  - 3. Memory Stops: Fully adjustable after insulation is installed.
- E. Memory Stops: Fully adjustable after insulation is installed.
- F. Valve-End Connections:
  - 1. Threaded End Valves: ASME B1.20.1.
  - 2. Flanges on Iron Valves: ASME B16.1 for flanges on iron valves.
  - 3. Pipe Flanges and Flanged Fittings 1/2 inch through 24 inch: ASME B16.5.
  - 4. Solder Joint Connections: ASME B16.18.
  - 5. Grooved End Connections: AWWA C606.
- G. General ASME Compliance:
  - 1. Ferrous Valve Dimensions and Design Criteria: ASME B16.10 and ASME B16.34.
  - 2. Building Services Piping Valves: ASME B31.9.
- H. Bronze Valves:

1. Fabricate from dezincification resistant material.
  2. Hot Forged Brass is an approved material from Bonomi only.
  3. Copper alloys containing more than 15 percent zinc are not permitted.
- I. Valve Bypass and Drain Connections: MSS SP-45.
- J. Source Limitations: Obtain each valve type from a single manufacturer.

### **2.03 BRONZE, BALL VALVES**

- A. General:
1. Fabricate from dezincification resistant material.
  2. Copper alloys containing more than 15 percent zinc are not permitted.
- B. Two Piece, Full Port with brass Trim:
1. Comply with MSS SP-110.
  2. WSP Rating: 150 psi.
  3. WOG Rating: 400 psi.
  4. Body: Forged bronze or dezincified-brass alloy.
  5. Ends: Solder or threaded with union.
  6. Seats: PTFE.
  7. Stem: Bronze or brass.
  8. Ball: Chrome plated brass.
  9. Manufacturers:
    - a. Apollo Valves: [www.apollovalves.com/#sle](http://www.apollovalves.com/#sle).
    - b. Jomar Valves, a division of Jomar Group: [www.jomarvalve.com/#sle](http://www.jomarvalve.com/#sle).
    - c. Bonomi North America [www.bonominorthamerica.com](http://www.bonominorthamerica.com)
    - d. Tyco Flow Control: [www.tycoflowcontrol.com](http://www.tycoflowcontrol.com)
    - e. Victaulic Company: [www.victaulic.com](http://www.victaulic.com)
    - f. Milwaukee Valve Company: [www.milwaukeevalve.com](http://www.milwaukeevalve.com)
    - g. Kitz Corporation of America: [www.kitz.com](http://www.kitz.com)
    - h. Nibco Valves: [www.nibco.com/#sle](http://www.nibco.com/#sle)
    - i. ASC-Engineered Solutions [www.asc-es.com](http://www.asc-es.com)
    - j. Substitutions: See Section 01 6000 - Product Requirements.

### **2.04 IRON, SINGLE FLANGE BUTTERFLY VALVES**

- A. Lug Style; Bidirectional Dead-End Service without Use of Downstream Flange:
1. Comply with MSS SP-67, Type I.
  2. Lug Style, CWP Ratings:
    - a. Sizes 2 to 12 inch: 150 psi.
  3. Body Material: ASTM A126 cast iron or ASTM A536 ductile iron.
  4. Stem: Stainless steel with stem offset from the centerline to provide full 360 degree circumferential setting.
  5. Seat: replaceable EPDM.
  6. Disc: Construct of aluminum bronze, chrome plated ductile iron, stainless steel, ductile iron with EPDM encapsulation, or Buna-N encapsulation.
  7. Operator: 10 position lever handle.
  8. Manufacturers:
    - a. Apollo Valves: [www.apollovalves.com/#sle](http://www.apollovalves.com/#sle).
    - b. Jomar Valves, a division of Jomar Group: [www.jomarvalve.com/#sle](http://www.jomarvalve.com/#sle).
    - c. Kitz Corporation of America: [www.kitzus-kca.com/#sle](http://www.kitzus-kca.com/#sle).
    - d. Nexus Valve, Inc: [www.nexusvalve.com/#sle](http://www.nexusvalve.com/#sle).
    - e. ASC-Engineered Solutions [www.asc-es.com](http://www.asc-es.com).
    - f. ABZ Valves and Controls.
    - g. Hammond Valve: [www.hammondvalve.com](http://www.hammondvalve.com)
    - h. Pratt Industrial [www.prattindl.com](http://www.prattindl.com)
    - i. Victaulic Company: [www.victaulic.com](http://www.victaulic.com)
    - j. Substitutions: See Section 01 6000 - Product Requirements.

## 2.05 IRON, GROOVED-END BUTTERFLY VALVES

- A. CWP Rating: 175 psi.
  - 1. Comply with MSS SP-67, Type I.
  - 2. Body: Coated ductile iron.
  - 3. Stem: Two-piece stainless steel.
  - 4. Disc: Coated ductile iron.
  - 5. Disc Seal: EPDM.
  - 6. Operator: 10 position lever handle.
  - 7. Manufacturers:
    - a. Kitz Corporation of America: [www.kitzus-kca.com/#sle](http://www.kitzus-kca.com/#sle).
    - b. Apollo Valves: [www.apollovalves.com/#sle](http://www.apollovalves.com/#sle).
    - c. Bonomi North America [www.bonominorthamerica.com](http://www.bonominorthamerica.com)
    - d. Tyco Flow Control: [www.tycoflowcontrol.com](http://www.tycoflowcontrol.com).
    - e. ABZ Valves and Controls.
    - f. Hammond Valve: [www.hammondvalve.com](http://www.hammondvalve.com)
    - g. Gruvlok by ASC Engineered Solutions [www.asc-es.com](http://www.asc-es.com)
    - h. Victaulic Company: [www.victaulic.com](http://www.victaulic.com)
    - i. Substitutions: See Section 01 6000 - Product Requirements.

## 2.06 BRONZE, SWING CHECK VALVES

- A. Class 125:
  - 1. Pressure and Temperature Rating: MSS SP-80, Type 3.
  - 2. Design: Y-pattern, horizontal or vertical flow.
  - 3. WSP Rating: 200 psi.
  - 4. Body: Bronze, ASTM B62.
  - 5. End Connections: Threaded or soldered.
  - 6. Disc: Bronze.
  - 7. Manufacturers:
    - a. Apollo Valves: [www.apollovalves.com/#sle](http://www.apollovalves.com/#sle).
    - b. ASC Engineered Solutions [www.asc-es.com](http://www.asc-es.com)
    - c. Kitz Corporation of America: [www.kitzus-kca.com/#sle](http://www.kitzus-kca.com/#sle).
    - d. Tyco Flow Control: [www.tycoflowcontrol.com](http://www.tycoflowcontrol.com)
    - e. Victaulic Company: [www.victaulic.com](http://www.victaulic.com)
    - f. Substitutions: See Section 01 6000 - Product Requirements.

## 2.07 BRONZE SPRING LOADED CHECK VALVES

- A. Class 125: CWP Rating 200 psig (1380 kPa).
  - 1. Design: Vertical flow.
  - 2. Body: Bronze, ASTM B61 or ASTM B62
  - 3. Spring: Bronze
  - 4. Ends: Threaded or soldered.
  - 5. Disc: Nonmetallic
  - 6. Manufacturers:
    - a. Milwaukee: [www.milwaukeevalve.com](http://www.milwaukeevalve.com)
    - b. Apollo Valves[<>]: [www.apollovalves.com/#sle](http://www.apollovalves.com/#sle).
    - c. ASC Engineered Solutions [www.asc-es.com](http://www.asc-es.com)
    - d. Bonomi [www.bonominorthamerica.com](http://www.bonominorthamerica.com) Hot Forged Brass Material approved
    - e. Substitutions: See Section 01 6000-Product Requirements.

## 2.08 IRON, FLANGED END SWING CHECK VALVES

- A. Class 125:
  - 1. 150 psi with metal seats.
  - 2. 200 psi with metal seats and nonmetallic-to-metal seats.
- B. Design: Clear or full waterway with flanged ends.

- C. Body: Gray iron with bolted bonnet in accordance with ASTM A126.
- D. Trim: Bronze.
- E. Disc: Stainless steel, bronze, or bronze faced rotating swing. Renewable disc and seat.
- F. Gasket: Asbestos free.
- G. Manufacturers:
  - 1. Apollo Valves: [www.apollovalves.com/#sle](http://www.apollovalves.com/#sle).
  - 2. Bonomi North America [www.bonominorthamerica.com](http://www.bonominorthamerica.com)
  - 3. ASC Engineered Solutions [www.asc-es.com](http://www.asc-es.com).
  - 4. Kitz Corporation of America.
  - 5. Tyco Flow Control: [www.tycoflowcontrol.com](http://www.tycoflowcontrol.com)
  - 6. Victaulic Company: [www.victaulic.com](http://www.victaulic.com)
  - 7. Titan Flow: [www.titanfci.com](http://www.titanfci.com)
  - 8. Substitutions: See Section 01 6000 - Product Requirements.

## **2.09 IRON, GROOVED-END SWING CHECK VALVES**

- A. Class 300:
  - 1. Body Material: ASTM A536, Grade 65-45-12 ductile iron.
  - 2. Seal: EPDM or Nitrile.
  - 3. Disc: Stainless steel.
  - 4. Coating: Black, non-lead paint.
  - 5. Manufacturers:
    - a. Gruvlok by ASC Engineered Solutions [www.asc-es.com](http://www.asc-es.com).
    - b. Kitz Corporation of America.
    - c. Tyco Flow Control: [www.tycoflowcontrol.com](http://www.tycoflowcontrol.com)
    - d. Victaulic Company: [www.victaulic.com](http://www.victaulic.com)
    - e. Titan Flow: [www.titanfci.com](http://www.titanfci.com)
    - f. Substitutions: See Section 01 6000 - Product Requirements.

## **2.10 IRON, PLATE-TYPE, SPRING LOADED CHECK VALVES**

- A. Class 125 Dual-Plate:
  - 1. Comply with API STD 594.
  - 2. Sizes 2-1/2 to 12 inch: CWP Rating; 200 psi.
  - 3. Body Design: Wafer or threaded lug ends, spring-loaded plates.
  - 4. Body Material: ASTM A126, gray iron.
  - 5. Trim: Bronze.
  - 6. Resilient Seat: EPDM.
  - 7. Spring: Stainless steel.
  - 8. Manufacturers:
    - a. Tyco Flow Control: [www.tycoflowcontrol.com](http://www.tycoflowcontrol.com).
    - b. Bonomi North America [www.bonominorthamerica.com](http://www.bonominorthamerica.com)
    - c. Crane Co.: [www.cranvalve.com](http://www.cranvalve.com)
    - d. Kitz Corporation of America.
    - e. Victaulic Company: [www.victaulic.com](http://www.victaulic.com)
    - f. Titan Flow: [www.titanfci.com](http://www.titanfci.com)
    - g. Substitutions: See Section 01 6000 - Product Requirements.

## **2.11 COMBINATION FLOW MEASURING AND BALANCING VALVE**

- A. Manufacturers:
  - 1. Griswold Controls
  - 2. Nexus
  - 3. Flow Design
- B. Construction:

1. Manual Flow Control devices shall be fixed orifice venturi, modified venturi, or pitot balancing type accurate to at least +/- 3%.
2. Valves 2-1/2" and smaller shall be modified venturi style, forced brass body and with integrated ball valve, (2) pressure/temperature test ports, additional port for air vent or drain valve, a tag indicating the model and Cv, memory stop with graduated scale, blowout proof stem with dual O-ring seals, interchangeable union end with O-ring seal, hard chrome plated ball with Teflon seats, and rated at 600 PSI WOG, 325 degrees F.
3. Valves 2-1/2" and larger shall be venturi or pitot balancing type accurate to at least +/- 3%.
  - a. Venturi balancing type shall be a flanged carbon steel ST37 body (per ASME B16.5, Class 150 Flanges); butterfly valve with infinite position memory stop and 316 stainless steel disc. Valve shall have (2) 1/4" NPT ports and be rated for 230 PSI, 250 degrees F.
  - b. Pitot tube balancing type shall be flanged cast iron body (per ASTM A126, Class B Flanges) metering station with stainless steel pitot tube; a tag indicating the model and Cv; butterfly valve with infinite position memory stop and 316 stainless steel disc. Valve shall have a minimum, (2) 1/4" NPT ports, (1) 1/2" NPT port and (1) additional 3/4" NPT port. Valve shall be rated at 175 PSI, 275 degrees F.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Discard all packing materials and verify that valve interior, including threads and flanges, are completely clean without signs of damage or degradation that could result in leakage.
- B. Verify valve parts to be fully operational in all positions from closed to fully open.
- C. Confirm gasket material to be suitable for the service, to be of correct size, and without defects that could compromise effectiveness.
- D. Should valve is determined to be defective, replace with new valve.

#### **3.02 INSTALLATION**

- A. Provide unions or flanges with valves to facilitate equipment removal and maintenance while maintaining system operation and full accessibility for servicing.
- B. Provide separate valve support as required and locate valve with stem at or above center of piping, maintaining unimpeded stem movement.
- C. Install valves with stems upright or horizontal, not inverted.
- D. Install check valves where necessary to maintain direction of flow as follows:
  1. Swing Check: Install horizontal maintaining hinge pin level.
  2. Orient plate-type and center-guided into horizontal or vertical position, between flanges.

**END OF SECTION**



**SECTION 23 0553  
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Nameplates.
- B. Tags.
- C. Pipe markers.

**1.02 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.

**PART 2 PRODUCTS**

**2.01 NAMEPLATES**

- A. Manufacturers:
  - 1. Kolbi Pipe Marker Co: [www.kolbipipemarkers.com/#sle](http://www.kolbipipemarkers.com/#sle).
  - 2. Seton Identification Products, a Tricor Direct Company: [www.seton.com/#sle](http://www.seton.com/#sle).
  - 3. Brady Corporation: [www.bradycorp.com](http://www.bradycorp.com).
  - 4. Champion America, Inc: [www.champion-america.com](http://www.champion-america.com).
  - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Letter Color: White.
- C. Letter Height: 1/4 inch.
- D. Background Color: Black.

**2.02 TAGS**

- A. Manufacturers:
  - 1. Kolbi Pipe Marker Co: [www.kolbipipemarkers.com/#sle](http://www.kolbipipemarkers.com/#sle).
  - 2. Seton Identification Products, a Tricor Company: [www.seton.com/#sle](http://www.seton.com/#sle).
  - 3. Brady Corporation: [www.bradycorp.com](http://www.bradycorp.com).
  - 4. Champion America, Inc: [www.champion-america.com](http://www.champion-america.com).
  - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.
- D. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

**2.03 PIPE MARKERS**

- A. Manufacturers:
  - 1. Kolbi Pipe Marker Co: [www.kolbipipemarkers.com/#sle](http://www.kolbipipemarkers.com/#sle).
  - 2. Seton Identification Products, a Tricor Company: [www.seton.com/#sle](http://www.seton.com/#sle).
  - 3. Brady Corporation: [www.bradycorp.com](http://www.bradycorp.com).
  - 4. Champion America, Inc: [www.champion-america.com](http://www.champion-america.com).
  - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Color: Comply with ASME A13.1.

- C. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

### **PART 3 EXECUTION**

#### **3.01 PREPARATION**

- A. Degrease and clean surfaces to receive adhesive for identification materials.

#### **3.02 INSTALLATION**

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E. Identify boilers, pumps, heat transfer equipment, tanks, and water treatment devices with nameplates. Small devices, such as inline pumps, may be identified with tags.
- F. Identify control panels and major control components outside panels with nameplates.
- G. Identify thermostats relating to terminal boxes or valves with nameplates.
- H. Identify valves in main and branch piping with tags.
- I. Identify piping, concealed or exposed, with pipe markers. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction.

**END OF SECTION**

**SECTION 23 0593**  
**TESTING, ADJUSTING, AND BALANCING FOR HVAC & PLUMBING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Testing, adjustment, and balancing of hydronic systems.

**1.02 RELATED REQUIREMENTS**

- A. Section 23 0005 - Basic HVAC Requirements.

**1.03 REFERENCE STANDARDS**

- A. AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition; 2016.
- B. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems; 2008, with Errata (2019).
- C. NEBB (TAB) - Procedural Standard for Testing Adjusting and Balancing of Environmental Systems; 2019.
- D. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing; 2002.

**1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
  - 1. Submit to Engineer and Owner.
  - 2. Submit six weeks prior to starting the testing, adjusting, and balancing work.
  - 3. Include at least the following in the plan:
    - a. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
    - b. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
    - c. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
    - d. Final test report forms to be used.
    - e. Detailed step-by-step procedures for TAB work for each system and issue, including:
      - 1) Terminal flow calibration (for each terminal type).
      - 2) Diffuser proportioning.
      - 3) Branch/submain proportioning.
      - 4) Total flow calculations.
      - 5) Rechecking.
      - 6) Diversity issues.
    - f. Details of how TOTAL flow will be determined; for example:
      - 1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
      - 2) Water: Pump curves, circuit setter, flow station, ultrasonic, etc.
    - g. Confirmation of understanding of the outside air ventilation criteria under all conditions.
    - h. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).
    - i. Method of checking building static and exhaust fan and/or relief damper capacity.
    - j. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.
    - k. Procedures for formal deficiency reports, including scope, frequency and distribution.

- C. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
1. Submit to the the Engineer within two weeks after completion of testing, adjusting, and balancing.
  2. Revise TAB plan to reflect actual procedures and submit as part of final report.
  3. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Owner and Engineer and for inclusion in operating and maintenance manuals.
  4. Provide report complete with index page, with cover identification at front. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
  5. Include actual instrument list, with manufacturer name, serial number, date of use and date of calibration.
  6. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
  7. Units of Measure: Report data in both I-P (inch-pound) and SI (metric) units.
  8. Include the following on the title page of each report:
    - a. Name of Testing, Adjusting, and Balancing Agency.
    - b. Address of Testing, Adjusting, and Balancing Agency.
    - c. Telephone number of Testing, Adjusting, and Balancing Agency.
    - d. Project name.
    - e. Project location.
    - f. Report date.
- D. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

## **PART 2 PRODUCTS - NOT USED**

## **PART 3 EXECUTION**

### **3.01 GENERAL REQUIREMENTS**

- A. Perform total system balance in accordance with one of the following:
1. AABC (NSTSB), AABC National Standards for Total System Balance.
  2. ASHRAE Std 111, Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
  3. SMACNA (TAB).
- B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.
- C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.
- D. TAB Agency Qualifications:
1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
  2. Certified by one of the following:
    - a. AABC, Associated Air Balance Council: [www.aabc.com/#sle](http://www.aabc.com/#sle); upon completion submit AABC National Performance Guaranty.
    - b. NEBB, National Environmental Balancing Bureau: [www.nebb.org/#sle](http://www.nebb.org/#sle).
    - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: [www.tabbcertified.org/#sle](http://www.tabbcertified.org/#sle).
- E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.
- F. Approved TAB Agencies:
1. Enviro-Aire. 586.779.6200; <https://enviro-aire.com>
  2. Controls Solutions Inc. (CSI). 616.247.9422; <https://controlyourbuilding.com>
  3. Environmental Testing Services. 248.859.6100; <https://www.etsmi.com>.

4. Integrity Test and Balance, Inc. 231.929.0940
5. International Test and Balance, Inc. 248.559.5864
6. Air Solutions, Inc. 810.358.8644
7. Substitutions must be approved by Engineer during Bid Phase.

### **3.02 EXAMINATION**

- A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
  1. Systems are started and operating in a safe and normal condition.
  2. Temperature control systems are installed complete and operable.
  3. Proper thermal overload protection is in place for electrical equipment.
  4. Duct systems are clean of debris.
  5. Access doors are closed and duct end caps are in place.
  6. Hydronic systems are flushed, filled, and vented.
  7. Pumps are rotating correctly.
  8. Proper strainer baskets are clean and in place.
  9. Service and balance valves are open.
- B. Beginning of work means acceptance of existing conditions.

### **3.03 ADJUSTMENT TOLERANCES**

- A. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

### **3.04 RECORDING AND ADJUSTING**

- A. Ensure recorded data represents actual measured or observed conditions.
- B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- C. Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.
- D. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

### **3.05 WATER SYSTEM PROCEDURE**

- A. Adjust water systems to provide required or design quantities.
- B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- D. Effect system balance with automatic control valves fully open to heat transfer elements.
- E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
- F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

### **3.06 SCOPE**

- A. Test, adjust, and balance the following:
  1. HVAC Pumps.
  2. Boilers.
  3. Hydronic balancing valves.

### **3.07 MINIMUM DATA TO BE REPORTED**

- A. Building:
  - 1. Final differential pressure setpoint for hydronic systems and VAV air handling systems.
- B. Balance Valves:
  - 1. Model.
  - 2. Size.
  - 3. Cv.
  - 4. Water flow, design and actual.
  - 5. Water pressure drop, design and actual.
  - 6. Memory stop position when locked.
- C. Pumps:
  - 1. Identification/number.
  - 2. Manufacturer.
  - 3. Size/model.
  - 4. Impeller.
  - 5. Service.
  - 6. Design flow rate, pressure drop, BHP.
  - 7. Actual flow rate, pressure drop, BHP.
  - 8. Discharge pressure.
  - 9. Suction pressure.
  - 10. Total operating head pressure.
  - 11. Shut off, discharge and suction pressures.
  - 12. Shut off, total head pressure.
- D. Combustion Equipment:
  - 1. Boiler manufacturer.
  - 2. Model number.
  - 3. Serial number.
  - 4. Firing rate.
  - 5. Water flow rate, design and actual
  - 6. Burner manifold gas pressure.
  - 7. Ambient temperature.
  - 8. Heat output.

**END OF SECTION**

**SECTION 23 0713  
DUCT INSULATION**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Duct insulation.

**1.02 RELATED REQUIREMENTS**

- A. Section 23 0005 - Basic HVAC Requirements.
- B. Section 23 3100 - HVAC Ducts and Casings: Glass fiber ducts.

**1.03 REFERENCE STANDARDS**

- A. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2021.
- B. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013 (Reapproved 2019).
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023c.
- D. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

**1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide product data, description, thermal and/or acoustical characteristics, list of materials and thickness for each service, and locations for duct insulation and duct liners to be used on project.

**1.05 QUALITY ASSURANCE**

- A. Applicator Qualifications: Company specializing in performing the type of work specified in this section and approved by manufacturer.

**1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

**1.07 FIELD CONDITIONS**

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

**PART 2 PRODUCTS**

**2.01 REGULATORY REQUIREMENTS**

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

**2.02 GLASS FIBER, FLEXIBLE**

- A. Manufacturer:
  - 1. CertainTeed Corporation: [www.certainteed.com/#sle](http://www.certainteed.com/#sle).
  - 2. Johns Manville: [www.jm.com/#sle](http://www.jm.com/#sle).
  - 3. Knauf Insulation: [www.knaufinsulation.com/#sle](http://www.knaufinsulation.com/#sle).
  - 4. Owens Corning Corporation: [www.ocbuildingspec.com/#sle](http://www.ocbuildingspec.com/#sle).
  - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Insulation: ASTM C553; flexible, noncombustible blanket.

1. K value: 0.36 at 75 degrees F, when tested in accordance with ASTM C518.
  2. Maximum Water Vapor Absorption: 5.0 percent by weight.
- C. Vapor Barrier Jacket:
1. Kraft paper with glass fiber yarn and bonded to aluminized film.
  2. Secure with pressure-sensitive tape.
- D. Vapor Barrier Tape:
1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure-sensitive rubber-based adhesive.
- E. Tie Wire: Annealed steel, 16 gauge, 0.0508 inch diameter.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Verify that surfaces are clean, foreign material removed, and dry.

#### **3.02 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Insulated Ducts Conveying Air Below Ambient Temperature:
1. Provide insulation with vapor barrier jackets.
  2. Finish with tape and vapor barrier jacket.
  3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
  4. Insulate entire system, including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

#### **3.03 SCHEDULES**

- A. Combustion Air Duct:
1. Flexible Glass Fiber Duct Insulation: 1-1/2 inches thick.

**END OF SECTION**



**SECTION 23 0716  
HVAC EQUIPMENT INSULATION**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Equipment insulation.
- B. Jacketing and accessories.

**1.02 RELATED REQUIREMENTS**

- A. Section 09 9123 - Interior Painting: Painting insulation covering.
- B. Section 23 0553 - Identification for HVAC Piping and Equipment.
- C. Section 23 2114 - Hydronic Specialties.

**1.03 REFERENCE STANDARDS**

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus; 2019, with Editorial Revision (2023).
- B. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement; 2007 (Reapproved 2019).
- C. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2021.
- D. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013 (Reapproved 2019).
- E. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023c.
- F. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2022a, with Editorial Revision (2023).
- G. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

**1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for equipment scheduled.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

**1.06 FIELD CONDITIONS**

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

**PART 2 PRODUCTS**

**2.01 REGULATORY REQUIREMENTS**

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

**2.02 GLASS FIBER, FLEXIBLE**

- A. Manufacturers:

1. CertainTeed Corporation: [www.certainteed.com/#sle](http://www.certainteed.com/#sle).
  2. Johns Manville Corporation: [www.jm.com/#sle](http://www.jm.com/#sle).
  3. Owens Corning Corporation: [www.ocbuildingspec.com/#sle](http://www.ocbuildingspec.com/#sle).
  4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Insulation: ASTM C553; flexible, noncombustible.
1. K Value: 0.36 at 75 degrees F, when tested in accordance with ASTM C177 or ASTM C518.
  2. Maximum Service Temperature: 1,000 degrees F.
  3. Maximum Water Vapor Absorption: 5.0 percent by weight.
- C. Vapor Barrier Jacket: Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
1. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
  2. Secure with self-sealing longitudinal laps and butt strips.
  3. Secure with outward clinch expanding staples and vapor barrier mastic.
- D. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
- E. Vapor Barrier Lap Adhesive: Compatible with insulation.
- F. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

## **2.03 JACKETING AND ACCESSORIES**

- A. Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire-retardant lagging adhesive.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Factory Insulated Equipment: Do not insulate.
- C. Exposed Equipment: Locate insulation and cover seams in least visible locations.
- D. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
- E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.
- F. Insulated equipment containing fluids below ambient temperature; insulate entire system.
- G. Fiber glass insulated equipment containing fluids below ambient temperature; provide vapor barrier jackets, factory-applied or field-applied. Finish with glass cloth and vapor barrier adhesive.
- H. For hot equipment containing fluids over 140 degrees F, insulate flanges and unions with removable sections and jackets.
- I. Fiber glass insulated equipment containing fluids above ambient temperature; provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Finish with glass cloth and adhesive.
- J. Equipment in Mechanical Equipment Rooms or Finished Spaces: Finish with canvas jacket sized for finish painting.
- K. Cover glass fiber insulation with metal mesh and finish with heavy coat of insulating cement.
- L. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

### **3.02 SCHEDULE**

- A. Heating Systems:
1. Air Separators: 2"

**END OF SECTION**

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**SECTION 23 0719  
HVAC PIPING INSULATION**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Piping insulation.
- B. Jacketing and accessories.

**1.02 RELATED REQUIREMENTS**

- A. Section 23 2113 - Hydronic Piping

**1.03 REFERENCE STANDARDS**

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus; 2019, with Editorial Revision (2023).
- B. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement; 2007 (Reapproved 2019).
- C. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2022a.
- D. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2023).
- E. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023c.
- F. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2022a, with Editorial Revision (2023).
- G. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

**1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

**1.05 FIELD CONDITIONS**

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

**PART 2 PRODUCTS**

**2.01 REGULATORY REQUIREMENTS**

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

**2.02 GLASS FIBER, RIGID**

- A. Manufacturers:
  - 1. CertainTeed Corporation: [www.certainteed.com/#sle](http://www.certainteed.com/#sle).
  - 2. Johns Manville Corporation: [www.jm.com/#sle](http://www.jm.com/#sle).
  - 3. Knauf Insulation: [www.knaufinsulation.com/#sle](http://www.knaufinsulation.com/#sle).
  - 4. Owens Corning Corporation: [www.ocbuildingspec.com/#sle](http://www.ocbuildingspec.com/#sle).
  - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
  - 1. K Value: ASTM C177, 0.24 at 75 degrees F.
  - 2. Maximum Service Temperature: 850 degrees F.
  - 3. Maximum Moisture Absorption: 0.2 percent by volume.

- C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.
- D. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
- E. Vapor Barrier Lap Adhesive: Compatible with insulation.
- F. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.
- G. Indoor Vapor Barrier Finish:
  - 1. Vinyl emulsion type acrylic, compatible with insulation, black color.

### **2.03 JACKETING AND ACCESSORIES**

- A. PVC Plastic.
  - 1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
    - a. Minimum Service Temperature: 0 degrees F.
    - b. Maximum Service Temperature: 150 degrees F.
    - c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
    - d. Thickness: 10 mil, 0.010 inch.
    - e. Connections: Brush on welding adhesive.
  - 2. Covering Adhesive Mastic: Compatible with insulation.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Test piping for design pressure, liquid tightness, and continuity prior to applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

### **3.02 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Exposed Piping: Locate insulation and cover seams in least visible locations.
- D. Insulated Pipes Conveying Fluids Below Ambient Temperature:
  - 1. Insulate entire system, including fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.
- E. 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.
- F. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- G. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.
- H. Glass Fiber Insulated Pipes Conveying Fluids Above Ambient Temperature:
  - 1. Provide standard jackets, with or without vapor barrier, factory-applied, or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples.
  - 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
- I. Inserts and Shields:
  - 1. Application: Piping 1-1/2 inches diameter or larger.
  - 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
  - 3. Insert location: Between support shield and piping and under the finish jacket.

4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
  5. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- J. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, see Section 07 8400.

### **3.03 SCHEDULE**

- A. Heating Systems:
1. Heating Water Supply and Return:
    - a. Pipe Size Range: 3/4 to 1-1/2 inch: 1-1/2 inches thick.
    - b. Pipe Size Range: 2 to 12 inch: 2 inches thick.

**END OF SECTION**

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**SECTION 23 0913  
INSTRUMENTATION AND CONTROL DEVICES FOR HVAC**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Control panels.
- B. Control Valves:
  - 1. Ball valves with factory-mounted actuators.
  - 2. Butterfly valves with factory-mounted actuators.
  - 3. Electronic valve operators.
- C. Fan and pump motor run-status monitoring.
- D. Pipe-Mounted Sensors and Transmitters:
  - 1. Temperature sensors.
  - 2. Differential pressure transmitters.

**1.02 RELATED REQUIREMENTS**

- A. Section 23 0519 - Meters and Gauges for HVAC Piping.
- B. Section 23 2113 - Hydronic Piping.
- C. Section 23 2114 - Hydronic Specialties.
- D. Section 23 0923 - Direct-Digital Control System for HVAC.
- E. Section 26 0583 - Wiring Connections.
- F. Section 26 2726 - Wiring Devices.

**1.03 REFERENCE STANDARDS**

- A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating; 2018.
- B. ANSI/FCI 70-2 - Control Valve Seat Leakage; 2021.
- C. ASHRAE Std 135 - A Data Communication Protocol for Building Automation and Control Networks; 2020, with Errata (2023).
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2020.
- E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

**1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide description and engineering data for each control system component. Include sizing as requested. Provide data for each system component and software module.
- C. Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. Submit schedule of valves indicating size, flow, and pressure drop for each valve. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.
- D. Project Record Documents: Record actual location of control components, including panels, thermostats, and sensors.
  - 1. Revise shop drawings to reflect actual installation and operating sequences.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  - 1. See Section 01 6000 - Product Requirements for additional provisions.
  - 2. Extra Thermostats and Other Exposed Sensors: One of each type.

**1.05 WARRANTY**

- A. See Section 01 7800 - Closeout Submittals for additional warranty requirements.
- B. Correct defective work within a five year period after Substantial Completion.

## **PART 2 PRODUCTS**

### **2.01 EQUIPMENT - GENERAL**

- A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

### **2.02 CONTROL PANELS**

- A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gauges, pilot lights, push buttons and switches flush on cabinet panel face.
- B. NEMA 250, general purpose utility enclosures with enameled finished face panel.
- C. Provide common keying for all panels.

### **2.03 CONTROL VALVES**

- A. Performance Requirements:
  - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
  - 3. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements" to size products where indicated as delegated design.
  - 4. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.
  - 5. Backup Power Source: Systems and equipment served by a backup power source shall have associated control valve actuators served from a backup power source.
  - 6. Environmental Conditions:
    - a. Provide electric control valve actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control valve actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.
  - 7. Determine control valve sizes and flow coefficients by ISA 75.01.01.
  - 8. Control valve characteristics and rangeability shall comply with ISA 75.11.01.
  - 9. Selection Criteria:
    - a. Control valves shall be suitable for operation at following conditions:
      - 1) Chilled Water: 150 PSI.
      - 2) Condenser Water: 150 PSI.
      - 3) Heating Hot Water: 150 PSI.
      - 4) Geothermal Heat Pump Loop Water: 150 PSI.
    - b. Control valve shutoff classifications shall be FCI 70-2, Class IV or better unless otherwise indicated.
    - c. Valve pattern, three-way or straight through, shall be as indicated on Drawings.
    - d. Controls Valves shall have 50% valve authority.
    - e. Modulating straight-through pattern control valves shall have linear or equal percentage flow-throttling characteristics unless otherwise indicated.
    - f. Modulating three-way pattern water valves shall have linear or equal percentag flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position.
    - g. Modulating butterfly valves shall have linear or equal percentage flow-throttling characteristics.
    - h. Fail positions unless otherwise indicated:
      - 1) Chilled Water: Closed.
      - 2) Condenser Water: Open.
      - 3) Heating Hot Water: Open.
      - 4) Geothermal Heat Pump Loop Water: Open.
    - i. Globe-type control valves shall pass the design flow required with not more than 95 percent of stem lift unless otherwise indicated.

- j. Rotary-type control valves, such as ball and butterfly valves, shall have Cv falling between 65 and 75 degrees of valve full open position and minimum valve Cv between 15 and 25 percent of open position.
  - k. Selection shall consider viscosity, flashing, and cavitation corrections.
  - l. Minimum Cv shall be calculated at 10 percent of design flow, with a coincident pressure differential equal to the system design pump head.
  - m. In water systems, select modulating control valves for a design Cv based on a pressure drop of twice the device it is controlling with a minimum of 2.3 ft and maximum of 10 ft, unless otherwise reviewed by Engineer.
  - n. Two-position control valves shall be line size unless otherwise indicated.
  - o. In water systems, use ball- or globe-style control valves for two-position control for valves NPS 2 and smaller and butterfly style for valves larger than NPS 2.
  - p. Close Off Pressure: 200 psi
- B. Ball Valves with Factory-Mounted Actuators:
- 1. Manufacturers:
    - a. Belimo Aircontrols (USA), Inc: [www.belimo.com/#sle](http://www.belimo.com/#sle).
    - b. Flow Tech.
    - c. Substitutions: See Section 01 6000 - Product Requirements.
  - 2. Replacements in Kind: Provide pressure-independent type.
  - 3. Rangeability: 500 to 1.
  - 4. Leakage: Class IV (0.1 percent of rated capacity) per ANSI/FCI 70-2.
  - 5. Body Size:
    - a. Under 2-1/2 inches:
      - 1) Connection: NPT.
      - 2) Materials:
        - (a) Body: Brass.
        - (b) Flanges: Ductile iron.
        - (c) Ball: Chrome-plated brass.
        - (d) Stem: Nickel-plated brass.
        - (e) Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
        - (f) Seat: Graphite-reinforced PTFE with EPDM O-Ring backing.
        - (g) Stem Seal: EPDM O-Rings.
        - (h) Flow Control Disk: Thermoplastic synthetic-resin.
    - b. Service Temperature:
      - 1) Fluid Side: 0 to 284 degrees F liquid or 25 psig steam.
      - 2) Ambient Side: From minus 4 to 122 degrees F.
  - 6. Actuator Requirements:
    - a. Assembly: Factory-mounted.
    - b. Input: 0 to 5 VDC configured for proportional control.
    - c. Accessories: Provide with valve position indicator and manual override.
- C. Butterfly Valves with Factory-Mount Actuators:
- 1. Manufacturers:
    - a. Honeywell International, Inc: [buildingcontrols.honeywell.com/#sle](http://buildingcontrols.honeywell.com/#sle).
    - b. Johnson Controls International, PLC: [www.johnsoncontrols.com/#sle](http://www.johnsoncontrols.com/#sle).
    - c. Schneider Electric: [www.schneider-electric.us/#sle](http://www.schneider-electric.us/#sle).
    - d. Belimo Aircontrols (USA), Inc: [www.belimo.com/#sle](http://www.belimo.com/#sle).
    - e. Flow Tech.
    - f. Substitutions: See Section 01 6000 - Product Requirements.
  - 2. Iron body, stainless steel disc, resilient replaceable seat for service to 250 degrees F wafer or lug ends, extended neck.
  - 3. Hydronic Systems:
    - a. Rate for service pressure of 125 psig at 250 degrees F.

- b. 2-position valves shall be full line size.
- D. Electronic Valve Actuators:
- 1. Valves shall spring return to normal position as indicated on freeze, fire, or temperature protection.
  - 2. Select operator for full shut-off at maximum pump differential pressure.
  - 3. Position indicator and graduated scale on each actuator.
  - 4. Type: Motor operated, with or without gears, electric and electronic.
  - 5. Voltage: Voltage selection delegated to professional designing control system.
  - 6. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
  - 7. Function properly within a range of 85 to 120 percent of nameplate voltage.
  - 8. Construction:
    - a. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
    - b. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
    - c. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
  - 9. Field Adjustment:
    - a. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
    - b. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.
  - 10. Two-Position Actuators: Single direction, spring return or reversing type.
  - 11. Modulating Actuators:
    - a. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
    - b. Control Input Signal:
      - 1) Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs.
      - 2) One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
      - 3) Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10 and 4- to 20-mA signals.
      - 4) Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
      - 5) Programmable Multi-Function:
      - 6) Control Input, Position Feedback, and Running Time: Factory or field programmable.
      - 7) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
      - 8) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.
  - 12. Position Feedback:
    - a. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
    - b. Equip modulating actuators with a position feedback through voltage signal for remote monitoring.
    - c. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
  - 13. Fail-Safe:
    - a. Where indicated, provide actuator to fail to an end position.
    - b. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.

- c. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.
- 14. Integral Overload Protection:
  - a. Provide against overload throughout the entire operating range in both directions.
  - b. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.
- 15. Valve Attachment:
  - a. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
  - b. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
  - c. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.
- 16. Temperature and Humidity:
  - a. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
  - b. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.
- 17. Enclosure:
  - a. Suitable for ambient conditions encountered by application.
  - b. NEMA 250, Type 2 for indoor and protected applications.
  - c. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
  - d. Provide actuator enclosure with heater and control where required by application.
- 18. Stroke Time:
  - a. Operate valve from fully closed to fully open within 60 seconds.
  - b. Operate valve from fully open to fully closed within 60 seconds.
  - c. Move valve to failed position within 15 seconds.
  - d. Select operating speed to be compatible with equipment and system operation.
- 19. Sound:
  - a. Spring Return: 62 dBA.
  - b. Non-Spring Return: 45 dBA.

#### **2.04 FAN AND PUMP MOTOR RUN-STATUS MONITORING**

- A. Current Switches:
  - 1. Micro-Split Core: 2-state, On/Off digital output of motor status with adjustable trip point to detect belt loss or mechanical failure.
  - 2. Mini Split-Core: 2-state, On/Off digital output of inverter-duty motor status with adjustable trip point to detect belt loss or mechanical failure.
  - 3. Maximum AC Current Monitoring Value: 175 percent of rated motor current.
- B. Differential Pressure Switches:
  - 1. Fan Status: Select for adjustable range between 0 to 5 in-wc across fan discharge and external or fan inlet. Include static pressure tips.
  - 2. Pump Status: Select for adjustable range between 8 to 60 psi across pump discharge and suction sides. Include static pressure tips and 3-way valve manifold.

#### **2.05 PIPE-MOUNTED SENSORS AND TRANSMITTERS**

- A. Temperature Sensors:
  - 1. Pipe-mounted temperature probe tied to weather-resistant enclosure for direct insertion into compatible liquids or gases or inserted into intermediary thermal grease-filled pipe-well compatible with interfaced fluid.
  - 2. Sensor Type: 1,000 ohm Platinum RTD.
  - 3. Transmitter: Fitted within probe-interface enclosure, calibrated.
    - a. Hardwired Output: Two-wire, 4 to 20 mA, loop powered.
    - b. Accuracy: Plus/minus three percent, adjustable on the transmitter end.
  - 4. Accessories: Provide downstream PT test plug and brass pipe-well.

- B. Differential Pressure Transmitters:
- C. Differential Pressure Transmitters:
  - 1. Manufacturers:
    - a. Veris Industries: [www.veris.com/#sle](http://www.veris.com/#sle).
    - b. Substitutions: See Section 01 6000 - Product Requirements.
  - 2. General: Provide wet media differential pressure transducers with 10 ft (3.5 m) shielded cable, to allow remote pressure sensing capability.
    - a. Input Power: Class 2; 15 to 30 VDC, 24VAC nominal, 50/60 Hz.
    - b. Output: 3-wire transmitter; 4 to 20 mA, 0 to 5V, or 0 to 10V, selectable,
    - c. Sensor:
      - 1) Media Compatibility: 17 to 4 PH stainless steel.
      - 2) Status Indication: Dual color LED.
      - 3) Proof Pressure: 2x max. F.S. range.
      - 4) Burst Pressure: 5x max. F.S. range.
      - 5) Accuracy at 77 degrees F for less than or equal 20 ft:
      - 6) Surge Damping: Electronic; 1 second averaging.
      - 7) Long Term Stability: Plus/minus 0.25 percent.
    - d. Pressure Ranges:
      - 1) 0 psi to 50 psi (Gauge): 5 psid/10 psid/25 psid/50 psid (pressure differential).
    - e. Operating Conditions:
      - 1) Temperature Compensated Range:
        - (a) TC Zero less than 1.5 percent of product F.S. (full scale) per sensor.
    - f. Enclosure: NEMA 250, Type 4.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Verify existing conditions before starting work.
- B. Verify that systems are ready to receive work.
- C. Beginning of installation means installer accepts existing conditions.
- D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.
- E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.
- F. Ensure installation of components is complementary to installation of similar components.
- G. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

#### **3.02 INSTALLATION**

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Install in accordance with manufacturer's instructions.
- D. Provide valves with position indicators and with pilot positioners where sequenced with other controls.
- E. Mount control panels adjacent to associated equipment on vibration free walls or free-standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
- F. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.
- G. Provide conduit and electrical wiring in accordance with Division 26. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

**END OF SECTION**

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**SECTION 23 0915  
VARIABLE FREQUENCY DRIVES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Variable frequency drives. This specification is to cover a complete variable frequency motor drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor. The drive shall be designed specifically for variable torque applications.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements.
- B. Division 03 - Concrete: Concrete equipment pads.
- C. Section 23 0005 - Basic HVAC Requirements.
- D. Division 26 - Electrical

**1.03 REFERENCE STANDARDS**

- A. NEMA ICS 7.1
- B. NEMA ICS 7
- C. IEEE 519
- D. UL 508A
- E. UL 508

**1.04 SUBMITTALS**

- A. Contractor shall provide submittals for equipment listed herein. Refer to Division 01 - General Requirements for submittal procedures.
- B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.
- C. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.
- D. Manufacturer's Field Reports: Indicate start-up inspection findings.
- E. Qualifications: VFDs and options shall be UL listed as a complete assembly. The base VFD shall be UL listed for 100 KAIC without the need for input fuses. It is required that the drive manufacturer has an existing sales representative exclusively for HVAC products with expertise in HVAC systems and controls, and an independent service organization.

**1.05 WARRANTY**

- A. Warranty shall be twenty-four (24) months from the date of certified startup, not to exceed thirty (30) months from the date of manufacture. The warranty shall include all parts, labor, travel time and expenses.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

- A. ABB U.S.; Model ACH 550: [www.abb.us/drives.com](http://www.abb.us/drives.com).
- B. Danfoss
- C. Square D [www.squared.com](http://www.squared.com).

**2.02 DESCRIPTION**

- A. Variable Frequency Drives: The VFD shall be solid state, with a pulse width modulated (PWM) output. The VFD package, as specified herein, shall be enclosed in a NEMA 1 enclosure, completely assembled and tested by the manufacturer. The VFD shall employ a full wave rectifier, integral line reactors, capacitors and insulated gate bipolar transistors as the output switching device. The drive efficiency shall be 97 percent or better at full speed and full load. Fundamental power factor shall be 0.98 at all speeds and loads.

### 2.03 OPERATING REQUIREMENTS

- A. Rated Input Voltage: Input 460/480 VAC +/- 10 percent, 3-phase, 48-63 Hz or input 208/220/230/240 VAC +/- 10 percent 3-phase, 48-63 Hz Undervoltage trip at rated input -35 percent. Overvoltage trip at rated input +30 percent.
- B. Interrupt Rating: 65 kAIC, suitable for use on a circuit capable of delivering not more than 65,000 RMS symmetrical amps, 480V maximum.
- C. Output Frequency: 0 to 250 Hz. Operation above 60 Hz shall require programming changes to prevent inadvertent high-speed operation.
- D. Operating Conditions: 0 to 40C, less than 95 percent humidity, noncondensing.
- E. VFD Enclosure: The VFD package, as specified herein, shall be enclosed in a UL listed Type 1 enclosure, completely assembled and tested by the manufacturer.
- F. Input Signal: 4 to 20 mA DC.

### 2.04 COMPONENTS

- A. Display: All VFDs shall have the same customer interface, including digital display and keypad, regardless of horsepower rating. The keypad is to be used for local control, for setting all parameters and for stepping through the displays and menus. The keypad shall be removable, be capable of remote mounting, and have its own nonvolatile memory. The keypad shall include hand-off-auto membrane selections. When in "Hand" the VFD will be started and the speed will be controlled from the up/down arrows. When in "Off" the VFD will be stopped. When in "Auto" the VFD will start via an external speed reference. The drive shall incorporate "bumpless transfer" of speed reference when switching between "Auto" and "Hand" modes. There shall be fault reset and "Help" buttons on the keypad. The "Help" button shall include "on-line" assistance for programming and troubleshooting.
  - 1. The VFDs shall utilize preprogrammed application macros specifically designed to facilitate startup. The application macros shall provide on command to reprogram all parameters and customer interfaces for a particular application to reduce programming time. The VFD shall have two user macros to allow end-user to create and save custom settings.
  - 2. There shall be a built in time clock in the VFD keypad. The clock shall have a battery backup with a ten (10) year minimum lifespan. The clock shall be used to date and time stamp faults and record operation parameters at the time of fault. If the battery fails, the VFD shall automatically revert to hours of operation since initial power-up. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays. The VFD shall have a digital input that allows an override to the time clock, when in the off mode, for a programmable timeframe. There shall be four (4) separate, independent timer functions that have both weekday and weekend settings.
- B. Status Indicators: The following operating information displays shall be standard on the VFD digital display, All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of two operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words, alpha-numeric codes are not acceptable.
  - 1. Output Frequency.
  - 2. Motor Speed (RPM, percent or engineering units).
  - 3. Motor Current.
  - 4. Calculated Motor Torque.
  - 5. Calculated Motor Power (kW).
  - 6. DC Bus Voltage.

7. Output Voltage.
  8. Analog Input Values.
  9. Analog Output Values.
  10. Keypad Reference Values.
  11. Elapsed Time Meter (resettable).
  12. kWh meter (resettable).
  13. Digital Input Status.
  14. Digital Output Status.
  15. Ammeter.
- C. The VFD shall have the ability to automatically restart after an overcurrent, overvoltage, undervoltage or loss of input signal protective trip. The number of restart attempts, trial time and time between reset attempts shall be programmable.
1. The VFD shall be capable of starting into a rotating load and accelerate or decelerate to setpoint without safety tripping or component damage. The VFD shall also be capable of DC injection braking at start to stop a reverse spinning motor prior to ramp.
  2. The VFD shall be equipped with an automatic extended control power ride-through circuit, which will utilize the inertia of the load to keep the drive powered. Typical control power ride-through for a fan load shall be two (2) seconds minimum.
  3. If the input reference (4-20mA or 2-10V) is lost, the VFD shall give the user the option of either: stopping and displaying fault, running at a programmable preset speed, hold the VFD speed based on the last good reference received, or cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, relay output and or over the serial communication bus.
  4. The customer terminal strip shall be isolated from the line and ground.
  5. The drive shall employ current limit circuits to provide trip free operation: The slow current regulation limit circuit shall be variable to 150 percent (minimum) of the VFD's normal duty current rating. This adjustment shall be made via the keypad and shall be displayed in actual amps, not as a percent of full load. The current switch-off limit shall be fixed at 350 percent (minimum, instantaneous) of the VFD's normal duty current rating.
  6. The overload rating of the drive shall be 110 percent of its normal duty current rating for one minute in every ten minutes, 130 percent overload for two seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL Table 430-150 for 4-pole motors.
  7. The VFD shall have an integral 5 percent impedance line reactors to reduce the harmonics to the power line and to add protection from AC line transients. The VFD shall include a coordinated AC transient protection system consisting of 4-120 joule-rated MOV's (phase to phase and phase to ground), a capacitor clamp and 5 percent impedance reactors.
  8. The VFD shall be capable of sensing a loss of load (broken belt, no water in pump, etc.) and signal the loss of load condition. The drive shall be programmable to signal this condition via a keypad warning, relay output and or over the serial communications bus.
- D. VFD Adjustments: Three programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed. Two PID setpoint controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed loop control. There shall be a independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain setpoint of an independent process. All setpoints, process variables, etc, to be accessible from the serial communication network. Two programmable analog inputs shall accept a current or voltage signal for speed reference or for reference and actual signals for PID controller. Two programmable analog outputs (0-20 ma or 4-20 ma). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power, and other data. Six programmable digital inputs. Three programmable digital Form C relay outputs. Seven programmable preset speeds. Two independently adjustable accel and decel ramps.

- E. Serial Communications: The VFD shall have an RS-485 port as standard. The standard protocols shall be Modbus and Johnson Controls NS bus, with optional protocols for LonWorks, BACnet and Ethernet available. Serial communications capabilities shall include, but not be limited to: run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock/unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed/frequency, current, present torque, kilowatt hours, operating hours and drive temperature. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible. The VFD shall allow the DDC to control the drive's digital and analog outputs via the serial interface.
- F. Microprocessor based Bypass Controller: A complete factory wired and tested bypass system consisting of an input contactor, output contactor and bypass contactor. Overload protection shall be provided in both drive and bypass modes. Controller shall be manual or automatic (selectable) transfer to line power via contactors. A keypad to control the bypass controller shall be mounted on the enclosure door. The bypass keypad shall include a one-line diagram and status LED's to indicate the mode of operation, drive and bypass status, and ready and enable conditions. When in "Drive" mode, the bypass contactor is open and the drive output contactor is closed. In the "Bypass" position, the drive output contactor is open and the bypass controller is closed.
- G. Door Interlocks: Furnish mechanical means to prevent opening of equipment with power connected, or to disconnect power if door is opened; include means for defeating interlock by qualified persons.
- H. Safety Interlocks: Furnish terminals for remote contact to inhibit starting under both manual and automatic mode.
- I. Control Interlocks: Furnish terminals for remote contact to allow starting in automatic mode.
- J. Disconnecting Means: Include integral fused disconnect switch on the line side of each controller.

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION**

- A. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.
- B. Tighten accessible connections and mechanical fasteners after placing controller.
- C. Provide fuses in fusible switches; refer to Section 16491 for product requirements.
- D. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.
- E. Power wiring shall be completed by the electrical contractor.
- F. Make final adjustments to installed controller to assure proper operation of load system. Obtain performance requirements from installer of driven loads.

#### **3.02 MANUFACTURER'S FIELD SERVICES**

- A. Provide the service of the manufacturer's field representative to prepare and start controllers. Certified factory startup shall be provided for each drive by a factory-authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner and a copy kept on file at the manufacturer.

#### **3.03 DEMONSTRATION**

- A. Demonstrate operation of controllers in automatic and manual modes.

### **END OF SECTION**

**SECTION 23 0925  
DIRECT-DIGITAL CONTROL (DDC) SYSTEMS FOR HVAC**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Control Equipment
- B. Software

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements.
- B. Division 02 - Existing Conditions.
- C. Section 23 0005 - Basic HVAC Requirements.
- D. Section 23 0553 - Identification for HVAC Piping and Equipment.
- E. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- F. Section 23 0915 - Variable Frequency Drives.
- G. Section 23 2123 - Hydronic Pumps.
- H. Section 23 8148 - Water Source Heat Pumps.
- I. Division 26 - Electrical.

**1.03 REFERENCE STANDARDS**

- A. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

**1.04 DESCRIPTION**

- A. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and a web-based operator interface. Depict each mechanical system and building floor plan by a point-and-click graphic. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.
- B. The system shall directly control HVAC equipment as detailed on the drawings. Each zone controller shall provide occupied and unoccupied modes of operation by individual zone. Furnish energy conservation features such as optimal start and stop, night setback, request-based logic, and demand level adjustment of setpoints as specified in the sequence.
- C. System shall use open protocol communications to the operator workstation or web server and for communication between control modules.

**1.05 APPROVED CONTROL SYSTEMS INSTALLERS**

- A. Metro Controls.

**1.06 QUALITY ASSURANCE**

- A. Installer and Manufacturer Qualifications
  - 1. Installer shall have an established working relationship with the Control System Manufacturer.
  - 2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.
- B. Perform work in accordance with NFPA 70.
- C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

**1.07 CODES AND STANDARDS**

- A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:
1. National Electric Code (NEC)
  2. International Building Code (IBC)
    - a. Section 719 Ducts and Air Transfer Openings
    - b. Section 907 Fire Alarm and Detection Systems
    - c. Section 909 Smoke Control Systems
    - d. Chapter 28 Mechanical
  3. International Mechanical Code (IMC)
  4. ANSI/ASHRAE 135-2004: Data Communication Protocol for Building Automation and Control Systems (BACNET)

### 1.08 SYSTEM PERFORMANCE

- A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).
1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
  2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
  3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
  4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
  5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 15 sec.
  6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
  7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
  8. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.
  9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy as listed below:
    - a. Space Temperature: +/- 1 degrees F
    - b. Ducted Air: +/- 1 degrees F
    - c. Outside Air: +/- 2 degrees F
    - d. Dew Point: +/- 3 degrees F
    - e. Water Temperature: +/- 1 degrees F
    - f. Delta-T: +/- 0.25 degrees F
    - g. Relative Humidity: +/- 5% RH
    - h. Water Flow: +/- 1% of reading
    - i. Airflow (terminal): +/- 10% of full scale
      - 1) Accuracy applies to 10% - 100% of scale
    - j. Airflow (measuring stations): +/- 3% of reading
    - k. Air Pressure (ducts): +/- 0.1 in. w.g.
    - l. Air Pressure (space): +/- 0.01 in. w.g.
    - m. Water Pressure: +/- 2% of full scale
      - 1) For both absolute and differential pressure
    - n. Electrical (A, V, W, Power Factor): +/- 1% of reading
      - 1) Not including utility supplied meters

- o. Carbon Monoxide (CO): +/- 5% of reading
- p. Carbon Dioxide (CO<sub>2</sub>): +/- 50 ppm
- 10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances as listed below:
  - a. Air Pressure (0 to 6 in. w.g.): +/- 0.2 in. w.g.
  - b. Air Pressure (-0.1 to 0.1 in. w.g.): +/- 0.01 in. w.g.
  - c. Airflow: +/-10% of full scale
  - d. Space Temperature: +/- 2.0 degrees F
  - e. Duct Temperature: +/- 3 degrees F
  - f. Humidity: +/- 5% RH
  - g. Fluid Pressure (1 to 150 psi): +/- 1.5 psi
  - h. Fluid Pressure (0 to 50 in. w.g. differential): +/- 1.0 in. w.g.

### 1.09 SUBMITTALS

- A. Direct Digital Control System Hardware
  - 1. Complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
  - 2. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:
    - a. Direct digital controllers (controller panels)
    - b. Transducers and transmitters
    - c. Sensors (include accuracy data)
    - d. Actuators
    - e. Valves
    - f. Relays and switches
    - g. Control panels
    - h. Power supplies
    - i. Batteries
    - j. Operator interface equipment
    - k. Wiring
  - 3. Wiring diagrams and layouts for each control panel. Show termination numbers.
  - 4. Floor plan schematic diagrams indicating field sensor and controller locations.
  - 5. Riser diagrams showing control network layout, communication protocol, and wire types.
- B. Central System Hardware and Software
  - 1. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.
  - 2. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:
    - a. Central Processing Unit (CPU) or web server
    - b. Monitors
    - c. Keyboards
    - d. Power supplies
    - e. Battery backups
    - f. Interface equipment between CPU or server and control panels
    - g. Operating System software
    - h. Operator interface software
    - i. Color graphic software
    - j. Third-party software
  - 3. Schematic diagrams of control, communication, and power wiring for central system installation. Show interface wiring to control system.
  - 4. Network riser diagrams of wiring between central control unit and control panels.
- C. Controlled Systems

1. Riser diagrams showing control network layout, communication protocol, and wire types.
  2. Schematic diagram of each controlled system. Label control points with point names. Graphically show locations of control elements.
  3. Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
  4. Instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
  5. Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system. List I/O points and software points. Indicate alarmed and trended points.
  6. Sequence of Operations shall include both equipment with packaged controls and equipment with TCC provided controls - regardless of who is purchasing the equipment (i.e. Owner Furnished Equipment or Kitchen FSE Consultant furnished equipment). Tcc shall reac out to the Equipment Supplier for packaged controls and provide a detailed list of items by Equipment Supplier and by TCC. Sequence of Operations of packaged equipment shall match sequence as outlined on drawings. TCC maintains all responsibility for the control sequence of all Equipment, regardless of who furnishes.
- D. Training Materials: Provide course outline and materials for each class at least six weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary to meet Owner's needs. Engineer will review and approve course outlines and materials at least three weeks before first class.

#### **1.10 WARRANTY**

- A. Warrant work as follows:
1. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.
  2. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
  3. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
  4. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

#### **1.11 OWNERSHIP OF PROPRIETARY MATERIAL**

- A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:
1. Graphics
  2. Record drawings
  3. Database
  4. Application programming code
  5. Documentation

### **PART 2 PRODUCTS**

#### **2.01 MATERIALS**



- A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

## **2.02 COMMUNICATIONS**

- A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise an open protocol internetwork.
- B. Install new wiring and network devices as required to provide a complete and workable control network.
- C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.
- D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.
  - 1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
  - 2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.
- E. Controllers with real-time clocks shall synchronize with the building management system. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.
- F. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.
- G. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards specified by the Web Services Interoperability Organization (WS-I) Basic Profile 1.0 or higher. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.
  - 1. System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.
  - 2. System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.
  - 3. For read or write requests, the system shall require user name and password authentication and shall support SSL (Secure Socket Layer) or equivalent data encryption.
  - 4. System shall support discovery through a Web services connection or shall provide a tool available through the Operator Interface that will reveal the path/identifier needed to allow a third party Web services device to read data from or write data to any object in the system which supports this service.

## **2.03 OPERATOR INTERFACE**

- A. Operator Interface. Web server shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information. In addition to the primary operator interface, the system shall include a secondary interface compatible with a locally available commercial wireless network and viewable on a commercially available wireless device such as a Wireless Access Protocol (WAP) enabled cellular telephone or personal digital assistant (PDA). This secondary interface may be text-based and shall provide a summary of the most important data. As a minimum, the following capabilities shall be provided through this interface:
1. An operator authentication system that requires an operator to log in before viewing or editing any data, and which can be configured to limit the privileges of an individual operator.
  2. The ability to view and acknowledge any alarm in the system. Alarms or links to alarms shall be provided on a contiguous list so the operator can quickly view all alarms.
  3. A summary page or pages for each piece of equipment in the system. This page shall include the current values of all critical I/O points and shall allow the operator to lock binary points on or off and to lock analog points to any value within their range.
  4. Navigation links that allow the operator to quickly navigate from the home screen to any piece of equipment in the system, and then return to the home screen. These links may be arranged in a hierarchical fashion, such as navigating from the home screen to a particular building, then to a specific floor in the building, and then to a specific room or piece of equipment.
- B. Communication. Web server or workstation and controllers shall communicate using an open protocol communications language. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol.
- C. Hardware. Each workstation or web server shall consist of the following:
1. Hardware Base. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times as specified. Hard disk shall have sufficient memory to store system software, one year of data for trended points, and a system database at least twice the size of the existing database at system acceptance.
- D. Operator Functions. Operator interface shall allow each authorized operator to execute the following functions as a minimum:
1. Log In and Log Out. System shall require user name and password to log in to operator interface.
  2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.
  3. View and Adjust Equipment Properties. Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration.
  4. View and Adjust Operating Schedules. Operators shall be able to view scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.
  5. View and Respond to Alarms. Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.
  6. View and Configure Trends. Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.
  7. View and Configure Reports. Operators shall be able to run preconfigured reports, to view report results, and to customize report configuration to show data of interest.
  8. Manage Control System Hardware. Operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.

9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and of functions they can perform while logged in. Operators shall be able to add operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately.
- E. System Software.
1. Operating System. Web server shall have an industry-standard professional-grade operating system. Acceptable systems include Microsoft Windows XP Pro, Red Hat Linux, or Sun Solaris. Coordinate operating system type with the Owner.
  2. System Graphics. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.
    - a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
    - b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.
    - c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
    - d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).
- F. System Tools. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.
1. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
  2. Controller Memory Download. Operators shall be able to download memory from the system database to each controller.
  3. System Configuration. Operators shall be able to configure the system.
  4. Online Help. Context-sensitive online help for each tool shall assist operators in operating and editing the system.
  5. Security. System shall require a user name and password to view, edit, add, or delete data.
    - a. Operator Access. Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object. Authorized operators shall be able to vary and deny each operator's accessible functions based on equipment or geographic location.
    - b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.
    - c. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.
  6. System Diagnostics. System shall automatically monitor controller and I/O point operation. System shall announce controller failure and I/O point locking (manual overriding to a fixed value).

7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as detailed on the drawings.
8. Alarm Messages. Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.
9. Alarm Reactions. Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.
10. Alarm Maintenance. Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.
11. Trend Configuration. Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk.
12. Object and Property Status and Control. Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics, or through custom programs.
13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Standard Reports. Furnish the following standard system reports:
  - a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
  - b. Alarm Summary. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
  - c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:
    - 1) Alarm History.
    - 2) Trend Data. Operator shall be able to select trends to be logged.
    - 3) Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.
15. Custom Reports. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface.
16. Graphics Generation. Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text, and animation files to a background graphic using a mouse.
17. Graphics Library. Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.
18. Custom Application Programming. Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

- a. Language. Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
  - b. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.
  - c. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
  - d. Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.
  - e. Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
  - f. Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.
  - g. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.
    - 1) Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.
    - 2) System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.
- G. Portable Operator's Terminal. Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

## **2.04 CONTROLLER SOFTWARE**

- A. Building and energy management application software shall reside and operate in system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.
- B. Scheduling. System shall provide the following schedule options as a minimum:
  1. Weekly. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
  2. Exception. Operator shall be able to designate an exception schedule for each of the next 365 days. After an exception schedule has executed, system shall discard and replace exception schedule with standard schedule for that day of the week.
  3. Holiday. Operator shall be able to define 24 special or holiday schedules of varying length on a scheduling calendar that repeats each year.
- C. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

- D. Binary and Analog Alarms. See Paragraph 2.3.F.7 (Alarm Processing).
- E. Alarm Reporting. See Paragraph 2.3.F.9 (Alarm Reactions).
- F. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.
- G. Maintenance Management. System shall generate maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits.
- H. Sequencing. Application software shall sequence chillers, boilers, and pumps as detailed on the drawings.
- I. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs.
- J. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.
- K. Energy Calculations.
  - 1. System shall accumulate and convert instantaneous power (kW) or flow rates (L/s [gpm]) to energy usage data.
  - 2. System shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.
- L. Anti-Short Cycling. Binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.
- M. On and Off Control with Differential. System shall provide direct- and reverse-acting on and off algorithms with adjustable differential to cycle a binary output based on a controlled variable and setpoint.
- N. Runtime Totalization. System shall provide an algorithm that can totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit.

## **2.05 CONTROLLERS**

- A. General. Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified.
- B. Communication.
  - 1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
  - 2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
  - 3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
  - 4. Stand-Alone Operation. Each piece of equipment specified shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.
- C. Environment. Controller hardware shall be suitable for anticipated ambient conditions.
  - 1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).

2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).
- D. Keypad. Provide a local keypad and display for each BC and AAC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use. If the manufacturer does not normally provide a keypad and display for each BC and AAC, provide the software and any interface cabling needed to use a laptop computer as a Portable Operator's Terminal for the system.
- E. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.
- F. Serviceability.
  1. Controllers shall have diagnostic LEDs for power, communication, and processor.
  2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.
  3. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.
- G. Memory.
  1. Controller memory shall support operating system, database, and programming requirements.
  2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
  3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.
- H. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
- I. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

## **2.06 INPUT AND OUTPUT INTERFACE**

- A. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.
- B. Protection. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.
- C. Binary Inputs. Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.
- D. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to 10 pulses per second.
- E. Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.
- F. Binary Outputs. Binary outputs shall send an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.
- G. Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

- H. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.
- I. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

## **2.07 POWER SUPPLIES AND LINE FILTERING**

- A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
  - 1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.
    - a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
    - b. Line voltage units shall be UL recognized and CSA listed.
- B. Power Line Filtering.
  - 1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
  - 2. Dielectric strength of 1000 V minimum
  - 3. Response time of 10 nanoseconds or less
  - 4. Transverse mode noise attenuation of 65 dB or greater
  - 5. Common mode noise attenuation of 150 dB or greater at 40-100 Hz

## **2.08 AUXILIARY CONTROL DEVICES**

- A. Local Control Panels.
  - 1. Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel.
  - 2. Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.
  - 3. Each local panel shall have a control power source power switch (on-off) with overcurrent protection.

## **2.09 WIRING AND RACEWAYS**

- A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.
- B. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

## **2.10 FIBER OPTIC CABLE SYSTEM**

- A. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.
- B. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**



- A. Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Architect or Engineer for resolution before starting rough-in work.
- B. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.
- C. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to Engineer and obtain written instructions for changes necessary to accommodate Section 23 0923 work with work of others. Controls Contractor shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.

### **3.02 PROTECTION**

- A. Controls Contractor shall protect against and be liable for damage to work and to material caused by Contractor's work or employees.
- B. Controls Contractor shall be responsible for work and equipment until inspected, tested, and accepted. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

### **3.03 COORDINATION**

- A. Site.
  - 1. Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades. If installation without coordination causes interference with work of other trades, Contractor shall correct conditions without extra charge.
  - 2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.
- B. Test and Balance.
  - 1. Provide Test and Balance Contractor a single set of necessary tools to interface to control system for testing and balancing.
  - 2. Train Test and Balance Contractor to use control system interface tools.
  - 3. Provide a qualified technician to assist with testing and balancing the first 20 terminal units.
  - 4. Test and Balance Contractor shall return tools undamaged and in working condition at completion of testing and balancing.
- C. Life Safety.
  - 1. Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as indicated on drawings.
  - 2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as indicated on drawings.
  - 3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.
- D. Coordination with Other Controls. Integrate with and coordinate controls and control devices furnished or installed by others as follows.
  - 1. Communication media and equipment shall be provided as specified.
  - 2. Each supplier of a controls product shall configure, program, start up, and test that product to meet the sequences of operation detailed on the drawings.
  - 3. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
  - 4. Controls Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.

### **3.04 GENERAL WORKMANSHIP**

- A. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.
- B. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.
- C. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.
- D. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.
- E. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

### **3.05 FILED QUALITY CONTROL**

- A. Work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances.
- B. Continually monitor field installation for code compliance and workmanship quality.
- C. Contractor shall arrange for work inspection by local or state authorities having jurisdiction over the work.

### **3.06 WIRING**

- A. The control contractor shall be responsible to provide additional 120V power as required for temperature controls and building automation. Some circuits may be indicated on the electrical drawings (if applicable) or provided from existing controllers being removed. If additional circuits are required, coordinate with the electrical contractor and/or owner's representative for locations of available circuits and provide circuit breakers, wiring and conduit as necessary.
- B. The control contractor shall be responsible to provide low-voltage power supplies, wiring, conduit, etc. as necessary to power control, metering and monitoring devices.
- C. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26, and manufacturer's recommendations. Where the requirements of Section 23 09 23 differ from Division 26, Section 23 09 23 shall take precedence.
- D. NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by NEC and Division 26.
- E. Low-voltage wiring shall meet NEC Class 2 requirements. Subfuse low-voltage power circuits as required to meet Class 2 current limit.
- F. NEC Class 2 (current-limited) wires not in raceway but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.
- G. Install wiring in raceway where subject to mechanical damage and at levels below 3 m (10ft) in mechanical, electrical, or service rooms.
- H. Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.
- I. Do not install wiring in raceway containing tubing.
- J. Run exposed Class 2 wiring parallel to a surface or perpendicular to it and tie neatly at 3 m (10 ft) intervals.
- K. Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.
- L. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.
- M. Size raceway and select wire size and type in accordance with manufacturer's recommendations and NEC requirements.

- N. Include one pull string in each raceway 2.5 cm (1 in.) or larger.
- O. Use color-coded conductors throughout.
- P. Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.
- Q. Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 15 cm (6 in.) between raceway and high-temperature equipment such as steam pipes or flues.
- R. Adhere to requirements in Division 26 where raceway crosses building expansion joints.
- S. Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.
- T. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.
- U. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Do not use flexible metal raceway less than ½ in. electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.
- V. Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.
- W. Install signal and communication cable according to DDC system recommendations.
  - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
  - 2. Install exposed cable in raceway. Wiring and cable in mechanical rooms shall be installed in conduit.
  - 3. Install concealed cable in raceway.
  - 4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
  - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
  - 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
  - 7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
  - 8. Low voltage cabling shall be run separate from 120 volt control wiring.
  - 9. Input and output wiring shall be run in separate conduit systems.
  - 10. Analog inputs shall be run separate from digital inputs.
  - 11. Network cabling shall be run in separate conduit system.
  - 12. No control wiring splices are allowed.

### **3.07 COMMUNICATION WIRING**

- A. Communication wiring shall be low-voltage Class 2 wiring.
- B. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.
- C. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.
- D. Verify entire network's integrity following cable installation using appropriate tests for each cable.
- E. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.
- F. Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

- G. Label communication wiring to indicate origination and destination.
- H. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

### 3.08 FIBER OPTIC CABLE

- A. During installation do not exceed maximum pulling tensions specified by cable manufacturer. Post-installation residual cable tension shall be within cable manufacturer's specifications.
- B. Install cabling and associated components according to manufacturers' instructions. Do not exceed minimum cable and unjacketed fiber bend radii specified by cable manufacturer.

### 3.09 INSTALLATION OF SENSORS

- A. Install sensors according to manufacturer's recommendations.
- B. Mount sensors rigidly and adequately for operating environment.
- C. Install room temperature sensors on concealed junction boxes properly supported by wall framing.
- D. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.
- E. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.
- F. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 3 m (1 ft) of sensing element for each 1 m<sup>2</sup> (1 ft<sup>2</sup>) of coil area.
- G. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.
- H. Install outdoor air temperature sensors on north wall at designated location with sun shield.
- I. Differential Air Static Pressure.
  - 1. Supply Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
  - 2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
  - 3. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.
  - 4. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.
  - 5. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.
  - 6. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.
- J. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

### 3.10 WARNING LABELS

- A. Affix permanent warning labels to equipment that can be automatically started by the control system.
  - 1. Labels shall use white lettering (12-point type or larger) on a red background.
  - 2. Warning labels shall read as follows.
    - a. C A U T I O N: This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing

- B. Affix permanent warning labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.
  - 1. Labels shall use white lettering (12-point type or larger) on a red background.
  - 2. Warning labels shall read as follows.
    - a. **C A U T I O N**: This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

### **3.11 IDENTIFICATION OF HARDWARE AND WIRING**

- A. Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 5 cm (2 in.) of termination.
- B. Permanently label or code each point of field terminal strips to show instrument or item served.
- C. Label control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.
- D. Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement.
- E. Label room sensors related to terminal boxes or valves with nameplates.
- F. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.
- G. Label identifiers shall match record documents.

### **3.12 PROGRAMMING**

- A. Software Programming. Programming shall provide actions for each possible situation. Graphic- or parameter-based programs shall be documented. Text-based programs shall be modular, structured, and commented to clearly describe each section of the program.
  - 1. Application Programming. Provide application programming that adheres to the sequences of operation. Program documentation or comment statements shall reflect language used in sequences of operation.
  - 2. System Programming. Provide system programming necessary for system operation.
- B. Operator Interface.
  - 1. Standard Graphics. Provide graphics as specified in Section 23 09 23 Article 2.3 Paragraph E.2 (System Graphics). Show on each equipment graphic input and output points and relevant calculated points. Point information on graphics shall dynamically update.
  - 2. Install, initialize, start up, and troubleshoot operator interface software and functions (including operating system software, operator interface database, and third-party software installation and integration required for successful operator interface operation).

### **3.13 CONTROL SYSTEM CHECKOUT AND TESTING**

- A. Startup Testing. Complete startup testing to verify operational control system before notifying Owner of system demonstration. Provide Owner with schedule for startup testing. Owner may have representative present during any or all startup testing.
  - 1. Calibrate and prepare for service each instrument, control, and accessory equipment furnished under Section 23 09 23.
  - 2. Verify that control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
  - 3. Enable control systems and verify each input device's calibration. Calibrate each device according to manufacturer's recommendations.
  - 4. Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
  - 5. Verify that analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.

6. Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.
7. Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.
8. Alarms and Interlocks.
  - a. Check each alarm with an appropriate signal at a value that will trip the alarm.
  - b. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
  - c. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

### **3.14 CLEANING**

- A. On completion of work, check equipment furnished under this section for paint damage. Repair damaged factory-finished paint to match adjacent areas. Replace deformed cabinets and enclosures with new material and repaint to match adjacent areas.

### **3.15 TRAINING**

- A. Provide training for a designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.
- B. Instructors shall be factory-trained and experienced in presenting this material.
- C. Perform classroom training using a network of working controllers representative of installed hardware.

**END OF SECTION**

**SECTION 23 1123  
NATURAL-GAS PIPING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Pipe, pipe fittings, valves, and connections for natural gas piping systems.

**1.02 RELATED REQUIREMENTS**

- A. Section 23 0516 - Expansion Fittings and Loops for HVAC Piping.
- B. Section 23 0553 - Identification for HVAC Piping and Equipment.

**1.03 REFERENCE STANDARDS**

- A. ANSI Z21.18/CSA 6.3 - Gas Appliance Pressure Regulators; 2019.
- B. ANSI Z21.80/CSA 6.22 - Line Pressure Regulators; 2019.
- C. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2021.
- D. ASME B31.1 - Power Piping; 2022.
- E. ASME B31.9 - Building Services Piping; 2020.
- F. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2022.
- G. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2023a.
- H. MSS SP-78 - Gray Iron Plug Valves, Flanged and Threaded Ends; 2011.
- I. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends; 2010, with Errata .

**1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.

**1.05 QUALITY ASSURANCE**

- A. Valves: Manufacturer's name and pressure rating marked on valve body.

**PART 2 PRODUCTS**

**2.01 NATURAL GAS PIPING, ABOVE GRADE**

- A. Steel Pipe: ASTM A53/A53M, Grade B, Type F, Schedule 40 black.
  - 1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
  - 2. Joints: Threaded or welded to ASME B31.1.

**2.02 FLANGES, UNIONS, AND COUPLINGS**

- A. Unions for Pipe Sizes 3 Inches and Under:
  - 1. Ferrous Pipe: Class 150 malleable iron threaded unions.
- B. Flanges for Pipe Size Over 1 Inch:
  - 1. Ferrous Pipe: Class 150 malleable iron threaded or forged steel slip-on flanges; preformed neoprene gaskets.

**2.03 PIPE HANGERS AND SUPPORTS**

- A. Provide hangers and supports that comply with MSS SP-58.
  - 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
  - 2. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze hangers.
  - 3. Trapeze Hangers: Welded steel channel frames attached to structure.

4. Vertical Pipe Support: Steel riser clamp.

#### **2.04 BALL VALVES**

- A. Manufacturers:
  1. Apollo Valves: [www.apollovalves.com/#sle](http://www.apollovalves.com/#sle).
  2. Milwaukee Valve Company: [www.milwaukeevalve.com/#sle](http://www.milwaukeevalve.com/#sle).
  3. Nibco, Inc: [www.nibco.com/#sle](http://www.nibco.com/#sle).
  4. Jomar Valves: [www.jomarvalve.com](http://www.jomarvalve.com)
  5. Bonomi: [www.bonominorthamerica.com](http://www.bonominorthamerica.com)
  6. Substitutions: See Section 01 6000 - Product Requirements.
- B. Construction, 2 Inches and Smaller: MSS SP-110, Class 150, 400 psi CWP, bronze or hot forged brass body, 304 stainless steel or chrome plated brass or bronze ball, regular port, Teflon seats and stuffing box ring, blow-out proof stem, lever handle, solder or threaded ends with union.

#### **2.05 PLUG VALVES**

- A. Manufacturers:
  1. Flomatic Valves: [www.flomatic.com](http://www.flomatic.com).
  2. Homestead: [www.homesteadvalve.com](http://www.homesteadvalve.com)
  3. Norgas Controls: [www.norgascontrols.com](http://www.norgascontrols.com)
  4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Construction 2-1/2 Inches and Larger: MSS SP-78, 200 psi CWP, cast iron body and plug, pressure lubricated, Teflon or Buna N packing, flanged ends. Provide lever operator with set screw.

#### **2.06 LINE PRESSURE REGULATORS AND APPLIANCE REGULATORS INDICATORS**

- A. Manufacturers:
  1. Maxitrol Company: [www.maxitrol.com/#sle](http://www.maxitrol.com/#sle).
  2. Fisher
  3. Eaton
  4. Harper Wyman Co
  5. Pietro Fiorentini
  6. Substitutions: See Section 01 6000 - Product Requirements.
- B. Compliance Requirements:
  1. Appliance Regulator: ANSI Z21.18/CSA 6.3.
  2. Line Pressure Regulator: ANSI Z21.80/CSA 6.22.
- C. Provide with inlet and outlet pressure gage on piping.
- D. Regulator shall be capable of downturn from 10 psi (or max pressure required by Utility Company) to median pressure range of equipment served.
- E. Regulator to be "ventless" where installed indoors, as approved by AHJ.

### **PART 3 EXECUTION**

#### **3.01 PREPARATION**

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt, on inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

#### **3.02 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- C. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
- D. Install piping to maintain headroom, conserve space, and not interfere with use of space.



- E. Group piping whenever practical at common elevations.
- F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- G. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- H. Provide access where valves and fittings are not exposed.
- I. Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting.
- J. Install valves with stems upright or horizontal, not inverted.
- K. Pipe vents from gas pressure reducing valves to outdoors and terminate in weather proof hood.
- L. Sleeve pipes passing through partitions, walls and floors.
- M. Pipe Hangers and Supports:
  - 1. Install in accordance with ASME B31.9.
  - 2. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

### **3.03 APPLICATION**

- A. Install unions downstream of valves and at equipment or apparatus connections.
- B. Provide regulators at all pieces of equipment in project. Optionally, line regulators can be provided to protect groups of equipment from abnormal conditions that may cause pressure increases, including but not limited to unusual operating conditions of the Utility service regulator.
- C. Provide with drip leg and isolation valve as required by IFGC.

**END OF SECTION**

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**SECTION 23 2113  
HYDRONIC PIPING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Hydronic system requirements.
- B. Heating water piping, above grade.
- C. Equipment drains and overflows.
- D. Pipe hangers and supports.
- E. Unions, flanges, mechanical couplings, and dielectric connections.

**1.02 RELATED REQUIREMENTS**

- A. Section 23 0516 - Expansion Fittings and Loops for HVAC Piping.
- B. Section 23 0523 - General-Duty Valves for HVAC Piping.
- C. Section 23 0553 - Identification for HVAC Piping and Equipment.
- D. Section 23 0719 - HVAC Piping Insulation.
- E. Section 23 2114 - Hydronic Specialties.
- F. Section 23 2500 - HVAC Water Treatment: Pipe cleaning.

**1.03 REFERENCE STANDARDS**

- A. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators; 2023.
- B. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2021.
- C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2021.
- D. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2021.
- E. ASME B31.9 - Building Services Piping; 2020.
- F. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2022.
- G. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2023a.
- H. ASTM B32 - Standard Specification for Solder Metal; 2020.
- I. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2022.
- J. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2020.
- K. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2021a.
- L. ASTM D2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series); 2020.
- M. ASTM D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40; 2023.
- N. ASTM D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80; 2020.
- O. ASTM D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets; 2020.
- P. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers; 2024.
- Q. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications; 2007 (Reapproved 2019).

- R. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2019.
- S. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2020, with Errata (2023).
- T. AWWA C606 - Grooved and Shouldered Joints; 2022.
- U. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2018, with Amendment (2019).

#### **1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data:
  - 1. Include data on pipe materials, pipe fittings, and accessories.
  - 2. Show grooved joint couplings, fittings, and specialties on drawings and product submittals, specifically identified with the manufacturer's style or series designation.

#### **1.05 QUALITY ASSURANCE**

- A. Provide all grooved joint couplings, fittings, valves, specialties, and grooving tools from a single manufacturer.
- B. Coupling Manufacturer:
  - 1. Perform on-site training by factory-trained representative to the Contractor's field personnel in the proper use of grooving tools and installation of grooved joint products.
  - 2. Periodic job site visits by factory-trained representative to ensure best practices in grooved joint installation.
- C. Welder Qualifications: Certify in accordance with ASME BPVC-IX.

#### **1.06 FIELD CONDITIONS**

- A. Do not install underground piping when bedding is wet or frozen.

### **PART 2 PRODUCTS**

#### **2.01 HYDRONIC SYSTEM REQUIREMENTS**

- A. Comply with ASME B31.9 and applicable federal, state, and local regulations.
- B. Piping: Provide piping, fittings, hangers, and supports as required, as indicated, and as follows:
  - 1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
  - 2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
  - 3. Grooved mechanical joints may be used in accessible locations only.
    - a. Accessible locations include those exposed on interior of building, in pipe chases, and in mechanical rooms, aboveground outdoors, and as approved by Architect.
    - b. Use rigid joints unless otherwise indicated.
  - 4. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.
- C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions, or grooved couplings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.
- D. Valves: Provide valves where indicated:
  - 1. Provide drain valves where indicated, and if not indicated, provide at least at main shut-off, low points of piping, bases of vertical risers, and at equipment. Use 3/4 inch gate valves with cap; pipe to nearest floor drain.

#### **2.02 HEATING WATER PIPING, ABOVE GRADE**

- A. Steel Pipe: ASTM A53/A53M, Schedule 40, black, using one of the following joint types:
  - 1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.
  - 2. Threaded Joints: ASME B16.3, malleable iron fittings.

3. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn, using one of the following joint types:
  1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings.
    - a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
    - b. Braze: AWS A5.8M/A5.8 BCuP copper/silver alloy.
  2. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.

### **2.03 EQUIPMENT DRAINS AND OVERFLOWS**

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 galvanized; using one of the following joint types:
- B. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn; using one of the following joint types:
  1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings; ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
- C. PVC Pipe: ASTM D1785, Schedule 40, or ASTM D2241, SDR 21 or 26.
  1. Fittings: ASTM D2466 or D2467, PVC.
  2. Joints: Solvent welded in accordance with ASTM D2855.

### **2.04 PIPE HANGERS AND SUPPORTS**

- A. Provide hangers and supports that comply with MSS SP-58.
  1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
- B. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads or with wedge-shaped grooves in header piping to permit support and hanging in accordance with ASME B31.9.

### **2.05 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS**

- A. Unions for Pipe of 2 Inches and Less:
  1. Ferrous Piping: 150 psi brass or malleable iron, threaded.
  2. Copper Pipe: Bronze, soldered joints.
- B. Flanges for Pipe 2 Inches and Greater:
  1. Ferrous Piping: 150 psig forged steel, slip-on.
  2. Copper Piping: Bronze.
  3. Gaskets: 1/16 inch thick, preformed neoprene.
- C. Mechanical Couplings for Grooved and Shouldered Joints: Two or more curved housing segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and compress gasket.
  1. Dimensions and Testing: In accordance with AWWA C606.
  2. Mechanical Couplings: Comply with ASTM F1476.
  3. Bolts and Nuts: Hot dipped galvanized or zinc-electroplated steel.
  4. When pipe is field grooved, provide coupling manufacturer's grooving tools.
  5. Manufacturers:
    - a. Anvil International: [www.anvilintl.com/#sle](http://www.anvilintl.com/#sle).
    - b. Gruvlok by ASC Engineered Solutions [www.asc-es.com](http://www.asc-es.com)
    - c. Victaulic Company: [www.victaulic.com/#sle](http://www.victaulic.com/#sle).
    - d. Substitutions: See Section 01 6000 - Product Requirements.

## **PART 3 EXECUTION**

### **3.01 PREPARATION**

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.

- C. Remove scale and dirt on inside and outside before assembly.
- D. Prepare piping connections to equipment using jointing system specified.
- E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- F. After completion, fill, clean, and treat systems. See Section 23 2500 for additional requirements.

### 3.02 PIPING APPLICATIONS

- A. Heating water piping, above grade:
  - 1. Pipe sizes 3/4" - 2": Copper, soldered/brazed joints.
  - 2. Pipe sizes 2 1/2" and larger: Schedule 40 black steel, welded joints or grooved joints where allowed

### 3.03 INSTALLATION

- A. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- B. Install in accordance with manufacturer's instructions.
- C. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.
- D. Route piping in orderly manner, parallel to building structure, and maintain gradient.
- E. Install piping to conserve building space and to avoid interference with use of space.
- F. Group piping whenever practical at common elevations.
- G. Sleeve pipe passing through partitions, walls, and floors.
- H. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified.
- I. Slope piping and arrange to drain at low points.
- J. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- K. Grooved Joints:
  - 1. Install in accordance with the manufacturer's latest published installation instructions.
  - 2. Gaskets to be suitable for the intended service, molded, and produced by the coupling manufacturer.
- L. Pipe Hangers and Supports:
  - 1. Install in accordance with ASME B31.9, ASTM F708, or MSS SP-58.
  - 2. Install hangers to provide minimum 1/2-inch space between finished covering and adjacent work.
  - 3. Place hangers within 12 inches of each horizontal elbow.
  - 4. Use hangers with 1-1/2 inches minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
  - 5. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
  - 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
  - 7. Provide copper plated hangers and supports for copper piping.
- M. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. See Section 23 0719.
- N. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08 3100 .
- O. Use eccentric reducers to maintain top of pipe level.
- P. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc-rich primer to welds.

- Q. Install valves with stems upright or horizontal, not inverted.

### 3.04 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
  2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
  3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
  4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
  5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
  2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
  3. Isolate expansion tanks and determine that hydronic system is full of water.
  4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
  5. After hydrostatic test pressure has been applied for at least 4 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
  6. Prepare written report of testing.
- C. Perform the following before operating the system:
1. Open manual valves fully.
  2. Inspect pumps for proper rotation. Set makeup pressure-reducing valves for required system pressure.
  3. 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).
  4. Set temperature controls so all coils are calling for full flow.
  5. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
  6. Verify lubrication of motors and bearings.

**END OF SECTION**

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**SECTION 23 2114  
HYDRONIC SPECIALTIES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Expansion tanks.
- B. Air vents.
- C. Air separators.
- D. Strainers.
- E. Suction diffusers.
- F. Pump connectors.
- G. Combination pump discharge valves.
- H. Relief valves.

**1.02 RELATED REQUIREMENTS**

- A. Section 23 2113 - Hydronic Piping.
- B. Section 23 2500 - HVAC Water Treatment: Pipe cleaning.

**1.03 REFERENCE STANDARDS**

- A. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels; 2023.

**1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description and model.

**PART 2 PRODUCTS**

**2.01 AIR VENTS**

- A. Manufacturers:
  - 1. Armstrong International, Inc: [www.armstronginternational.com/#sle](http://www.armstronginternational.com/#sle).
  - 2. ITT Bell & Gossett: [www.bellgossett.com/#sle](http://www.bellgossett.com/#sle).
  - 3. Taco, Inc: [www.taco-hvac.com/#sle](http://www.taco-hvac.com/#sle).
  - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Manual Air Vent: Short vertical sections of 2-inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.
- C. Float Air Vent:
  - 1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
  - 2. Cast iron body and cover, float, bronze pilot valve mechanism suitable for system operating temperature and pressure; with isolating valve.
- D. Hygroscopic Air Vent:
  - 1. Brass with hygroscopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring-loaded ball check valve.
- E. Maximum Fluid Pressure: 150 psi.
- F. Maximum Fluid Temperature: 250 degrees F.

**2.02 AIR SEPARATORS**

- A. Coalescing Air/Dirt Separators:
  - 1. Manufacturers:

- a. Armstrong International, Inc: [www.armstronginternational.com/#sle](http://www.armstronginternational.com/#sle).
  - b. ITT Bell & Gossett: [www.bellgossett.com/#sle](http://www.bellgossett.com/#sle).
  - c. Spirotherm, Inc: [www.spirotherm.com/#sle](http://www.spirotherm.com/#sle).
  - d. Caleffi: [www.caleffi.com](http://www.caleffi.com).
  - e. Taco: [www.tacomfort.com](http://www.tacomfort.com).
  - f. Wessels: [www.westank.com](http://www.westank.com)
  - g. Grundfos: [www.grundfos.com](http://www.grundfos.com)
  - h. Substitutions: See Section 01 6000 - Product Requirements.
2. Tank: Fabricated steel tank; tested and stamped in accordance with ASME BPVC-VIII-1 for maximum fluid service subject to application requirements and manufacturer's standard maximum operating conditions.
  3. Air Vent: Integral float actuated air vent at top fitting of tank rated at 150 psi, threaded to top of separator.
  4. End Connections: Class 150 flanged for 2-1/2 inch and larger otherwise threaded.
  5. Blowdown Connection: Threaded.
  6. Size: Match system flow capacity.
  7. Maximum Fluid Service Pressure: 150 psi.
  8. Maximum Fluid Service Temperature: 250 degrees F.
  9. Accessories:
    - a. Provide with magnetic insert.
    - b. Comprised of neodymium 45H magnets with a strength of 13,550 Gauss, the magnetic rod helps remove metallic sediment that can pose a serious threat to modern system components. The insert can be easily moved from its position inside the separator to facilitate blow down and sediment removal.

### **2.03 STRAINERS**

- A. Manufacturers:
  1. Armstrong International, Inc: [www.armstronginternational.com/#sle](http://www.armstronginternational.com/#sle).
  2. Grinnell Products: [www.grinnell.com/#sle](http://www.grinnell.com/#sle).
  3. The Metraflex Company: [www.metraflex.com/#sle](http://www.metraflex.com/#sle).
  4. Titan Flow Control: [www.titanfci.com](http://www.titanfci.com).
  5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Size 2 inch and Under:
  1. Provide threaded, grooved, or sweat brass or iron body for up to 175 psi working pressure, Y-pattern strainer with 1/32 inch stainless steel perforated screen.
- C. Size 2-1/2 inch to 4 inch:
  1. Provide flanged iron body for 175 psi working pressure, Y pattern with 1/16 inch stainless steel perforated screen.
- D. Size 5 inch and Larger:
  1. Provide flanged iron body for 175 psi working pressure, basket pattern with 1/8 inch stainless steel perforated screen.
- E. Accessories: Provide blowdown vent/drain and outlet ball valve.

### **2.04 SUCTION DIFFUSERS**

- A. Manufacturers:
  1. Anvil International: [www.anvilintl.com/#sle](http://www.anvilintl.com/#sle).
  2. Bell & Gossett, a brand of Xylem, Inc: [www.bellgossett.com/#sle](http://www.bellgossett.com/#sle).
  3. Victaulic Company of America: [www.victaulic.com/#sle](http://www.victaulic.com/#sle).
  4. Taco: [www.tacohvac.com](http://www.tacohvac.com).
  5. Grundfos: [www.grundfos.com](http://www.grundfos.com)
  6. Substitutions: See Section 01 6000 - Product Requirements.

- B. Fitting: Angle pattern, cast-iron or ductile-iron body, threaded for 2 inch and smaller, flanged or grooved for 2-1/2 inch and larger, rated for 175 psi working pressure, with full-length, 4-plane removable straightening vanes made of carbon steel or 304 stainless steel, orifice cylinder shall be made of either carbon steel or 304 stainless steel, full-length cylinder strainer with 3/16 inch diameter openings, and 16 mesh full-length removable startup screen.
- C. Accessories: Adjustable foot support, blowdown tapping in bottom, gauge tapping in side.

## **2.05 PUMP CONNECTORS**

- A. Manufacturers:
  - 1. Anvil International: [www.anvilintl.com/#sle](http://www.anvilintl.com/#sle).
  - 2. The Metraflex Company: [www.metraflex.com/#sle](http://www.metraflex.com/#sle).
  - 3. Victaulic: [www.victaulic.com](http://www.victaulic.com).
  - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Flexible Connectors: Flanged, braided type with wetted components of stainless steel, sized to match piping.
  - 1. Maximum Allowable Working Pressure: 175 psig at 200 degrees F.
  - 2. End Connections: Same as specified for pipe jointing.
  - 3. Provide pump connector with integral vanes to reduce turbulent flow.
  - 4. Provide necessary accessories including, but not limited to, swivel joints and limit stops.

## **2.06 COMBINATION PUMP DISCHARGE VALVES**

- A. Manufacturers:
  - 1. Anvil International: [www.anvilintl.com/#sle](http://www.anvilintl.com/#sle).
  - 2. Crane Co.: [www.craneco.com/#sle](http://www.craneco.com/#sle).
  - 3. Taco, Inc: [www.taco-hvac.com/#sle](http://www.taco-hvac.com/#sle).
  - 4. Victaulic Company of America: [www.victaulic.com/#sle](http://www.victaulic.com/#sle).
  - 5. ITT Bell & Gossett: [www.bellgossett.com/#sle](http://www.bellgossett.com/#sle).
  - 6. Grundfos: [www.grundfos.com](http://www.grundfos.com)
  - 7. Substitutions: See Section 01 6000 - Product Requirements.
- B. The valve shall have a calibrated nameplate with multi-turn stem.
- C. The valve shall include a rubber memory button to allow the valve to be re-balanced to its original position after shut-off or maintenance.
- D. The valve shall have a fully backseating disc to allow the valve packing to be replaced while under pressure.
- E. The valve shall have a maximum temperature rating of 250°F (121°C).
- F. Accessories:
  - 1. Pressure/Temperature port.

## **2.07 RELIEF VALVES**

- A. Manufacturers:
  - 1. Apollo Valves: [www.apollovalves.com/#sle](http://www.apollovalves.com/#sle).
  - 2. Armstrong International, Inc: [www.armstronginternational.com/#sle](http://www.armstronginternational.com/#sle).
  - 3. ITT Bell & Gossett: [www.bellgossett.com/#sle](http://www.bellgossett.com/#sle).
  - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install specialties in accordance with manufacturer's instructions.
- B. Where large air quantities can accumulate, provide enlarged air collection standpipes.
- C. Provide manual air vents at system high points and as indicated.

- D. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.
- E. Provide air separator on suction side of system circulation pump and connect to expansion tank.
- F. Provide valved drain and hose connection on strainer blowdown connection.
- G. Provide pump suction fitting on suction side of base-mounted centrifugal pumps. Remove temporary strainers after cleaning systems.
- H. Provide combination pump discharge valve on discharge side of pumps where indicated.
- I. Support pump fittings with floor-mounted pipe and flange supports.
- J. Provide relief valves on pressure tanks, low-pressure side of reducing valves, heat exchangers, and expansion tanks.
- K. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
- L. Pipe relief valve outlet to nearest floor drain.
- M. Where one line vents several relief valves, make cross-sectional area equal to sum of individual vent areas.
- N. Install floor mounted equipment on 4" housekeeping pad, unless otherwise noted.
- O. Clean and flush glycol system before adding glycol solution, see Section 23 2500.
- P. Feed glycol solution to system through make-up line with pressure regulator, venting system high points.

**END OF SECTION**

**SECTION 23 2123  
HYDRONIC PUMPS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. System-lubricated circulators.
- B. Circulators.
- C. End-suction pumps.

**1.02 RELATED REQUIREMENTS**

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 23 0719 - HVAC Piping Insulation.
- C. Section 23 0934 - Variable-Frequency Motor Controllers for HVAC.
- D. Section 23 2113 - Hydronic Piping.
- E. Section 23 2114 - Hydronic Specialties.
- F. Section 26 0583 - Wiring Connections.

**1.03 REFERENCE STANDARDS**

- A. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- B. UL 778 - Standard for Motor-Operated Water Pumps; Current Edition, Including All Revisions.

**1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  - 1. See Section 01 6000 - Product Requirements, for additional provisions.
  - 2. Extra Pump Seals: One set for each type and size of pump.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

- A. Bell & Gossett, a Xylem Inc. brand: [www.bellgossett.com/#sle](http://www.bellgossett.com/#sle).
- B. Other manufacturers by voluntary alternate.
- C. Substitutions: See Section 01 6000 - Product Requirements.

**2.02 GENERAL**

- A. Provide pumps that operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.
- B. Electrical Requirements:
  - 1. Listed and classified by UL or testing agency acceptable to authority having jurisdiction as suitable for the purpose specified and indicated.
  - 2. Variable Frequency Drives (VFDs): Provide in accordance with Section 23 0934, except for integral-VFDs.
  - 3. Enclosures: Provide unspecified product(s) required to fit motor:

**2.03 END-SUCTION PUMPS**

- A. Split-Coupled Pump: Base-mounted, single-stage pump with horizontal shaft and radially- or horizontally-split casing rated for discharge pressures up to 175 psi.

- B. Casing: Cast iron or ductile iron with renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction, and discharge flanged connections with gauge ports.
- C. Impeller: Stainless steel, balanced, fully enclosed, keyed to shaft.
- D. Bearings: Oil lubricated roller or ball bearings.
- E. Shaft: Alloy steel with copper, bronze, or stainless steel shaft sleeve.
- F. Seal: Mechanical, 225 degrees F maximum continuous duty temperature.
- G. Drive: Flexible coupling with coupling guard.
- H. Baseplate: Cast iron or fabricated steel with integral drain rim.
- I. Motor: TEFC, NEMA premium efficiency, with factory installed Aegis shaft grounding rings.

### **PART 3 EXECUTION**

#### **3.01 PREPARATION**

- A. Verify that electric power is available and of the correct characteristics.

#### **3.02 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Provide access space around pumps for service. Provide no less than minimum space recommended by manufacturer.
- C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close-coupled or base-mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches and over.
- D. Provide line sized shut-off valve and strainer or pump suction fitting on pump suction, and line sized combination pump discharge valve or soft seat check valve and balancing valve and line sized shut-off valve on pump discharge.
- E. Provide air cock and drain connection on horizontal pump casings.
- F. Provide drains for bases and seals, piped to and discharging into floor drains.
- G. Check, align, and certify alignment of base-mounted pumps prior to start-up.
- H. Install close-coupled and base-mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place.
- I. Lubricate pumps before start-up.

**END OF SECTION**

**SECTION 23 2500  
HVAC WATER TREATMENT**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Water testing.
- B. Materials.
  - 1. System cleaner.
  - 2. Closed system treatment (water).

**1.02 RELATED REQUIREMENTS**

- A. Section 01 6000 - Product Requirements: Owner furnished treatment equipment.
- B. Section 23 2113 - Hydronic Piping.
- C. Section 23 2114 - Hydronic Specialties.

**1.03 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Water Quality Testing Report: Perform water quality testing for each project site prior to equipment installation and submittals. Tests shall include at a minimum, hardness, TDS and any other items as required by equipment (water heater, boiler, etc) manufacturers. Report shall be provided to Engineer and Owner for review.
- C. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
- D. Shop Drawings: Indicate system schematic, equipment locations, and controls schematics, electrical characteristics and connection requirements.
- E. Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.
- F. Project Record Documents: Record actual locations of equipment and piping, including sampling points and location of chemical injectors.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  - 1. See Section 01 6000 - Product Requirements, for additional provisions.
  - 2. Sufficient chemicals for treatment and testing during required maintenance period.

**1.04 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience. Company shall have local representatives with water analysis laboratories and full time service personnel.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

- A. AmSolv-Amrep, Inc: [www.amsolv.com/#sle](http://www.amsolv.com/#sle).
- B. GE Water & Process Technologies: [www.gewater.com/#sle](http://www.gewater.com/#sle).
- C. Nalco, an Ecolab Company: [www.nalco.com/#sle](http://www.nalco.com/#sle).
- D. H-O-H Water Technologies, Inc.
- E. Substitutions: See Section 01 6000 - Product Requirements.

**2.02 REGULATORY REQUIREMENTS**

- A. Comply with applicable codes for addition of non-potable chemicals to building mechanical systems and to public sewage systems.

**2.03 MATERIALS**

- A. System Cleaner:

1. Manufacturers:
    - a. As recommended by chemical treatment manufacturer..
  2. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products; sodiumtripoly phosphate and sodium molybdate.
- B. Closed System Treatment (Water):
1. Sequestering agent to reduce deposits and adjust pH.
  2. Corrosion inhibitors; boron-nitrite, sodium nitrite and borax, sodium totyltriazole, low molecular weight polymers, phosphonates, sodium molybdate, or sulphites.
  3. Conductivity enhancers; phosphates or phosphonates.

## **PART 3 EXECUTION**

### **3.01 PREPARATION**

- A. Systems shall be operational, filled, started, and vented prior to cleaning. The mechanical contractor shall meter the initial water fill for the purpose of hydrostatic pressure testing and/or system flushing. After completion of this requirement the water shall be metered out. This will provide the contractor with a precise measure of coolant required to fill the system as well as the amount of water trapped in the system. This process will allow for any adjustments required prior to delivery of the premixed glycol solution and ensure that the solution strength is in compliance with the specification.
- B. Place terminal control valves in open position during cleaning.
- C. Verify that electric power is available and of the correct characteristics.

### **3.02 CLEANING SEQUENCE**

- A. Concentration:
  1. As recommended by manufacturer.
- B. Hot Water Heating Systems:
  1. Apply heat while circulating, slowly raising temperature to 160 degrees F and maintain for 12 hours minimum.
  2. Remove heat and circulate to 100 degrees F or less; drain systems as quickly as possible and refill with clean water.
  3. Circulate for 6 hours at design temperatures, then drain.
  4. Refill with clean water and repeat until system cleaner is removed.
- C. Remove, clean, and replace strainer screens.
- D. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

### **3.03 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.

### **3.04 CLOSED SYSTEM TREATMENT**

- A. Introduce closed system treatment through bypass feeder when required or indicated by test.

### **3.05 CLOSEOUT ACTIVITIES**

- A. Training: Train Owner's personnel on operation and maintenance of chemical treatment system.
  1. Provide minimum of two hours of instruction for two people.
  2. Have operation and maintenance data prepared and available for review during training.
  3. Conduct training using actual equipment after treated system has been put into full operation.

### **3.06 MAINTENANCE**

- A. Perform maintenance work using competent and qualified personnel under the supervision and in the direct employ of the equipment manufacturer or original installer.
- B. Provide service and maintenance of treatment systems for one year from Date of Substantial Completion.



- C. Provide monthly technical service visits to perform field inspections and make water analysis on-site. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit two copies of field service report after each visit.
- D. Provide laboratory and technical assistance services during this maintenance period.

**END OF SECTION**

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**SECTION 23 3100  
HVAC DUCTS AND CASINGS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Metal ducts.
- B. Single-wall rectangular ducts and fittings.
- C. Single-wall round ducts and fittings.
- D. Sheet metal materials.
- E. Sealants and gaskets.
- F. Hangers and supports.

**1.02 RELATED REQUIREMENTS**

- A. Division 03 - Concrete
- B. Division 07 - Thermal Moisture Protection: Firestopping
- C. Section 23 0005 - Basic HVAC Requirements
- D. Section 23 0593 - Testing, Adjusting and balancing for HVAC
- E. Section 23 0713 - Duct Insulation: External insulation and duct liner.

**1.03 REFERENCE STANDARDS**

- A. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2023.
- B. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength; 2023.
- C. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- D. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- E. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Current Edition, Including All Revisions.

**1.04 PERFORMANCE REQUIREMENTS**

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

**1.05 REGULATORY REQUIREMENTS**

- A. Construct ductwork to SMACNA (DCS) - HVAC Duct Construction Standards - Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; Current Edition including all Addenda.

**PART 2 PRODUCTS**

**2.01 SINGLE-WALL ROUND DUCT AND FITTING ASSEMBLIES**

- A. Regulatory Requirements: Construct ductwork to comply with NFPA 90A standards.

- B. 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.
- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  - 1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
- E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

## 2.02 SEALANTS 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.
  - 3. Shore A Hardness: Minimum 20.
  - 4. Water resistant.
  - 5. Mold and mildew resistant.
  - 6. VOC: Maximum 75 g/L (less water).
  - 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
  - 8. Service: Indoor or outdoor.
  - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- C. 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 pressure class, positive or negative.

## 2.03 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. 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.

- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
  - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
  - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
  - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

## **2.04 METAL DUCTS**

## **2.05 METAL DUCTS**

- A. Material Requirements:
  - 1. 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.
  - 2. Galvanized Steel: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G90/Z275 coating.
  - 3. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
    - a. Galvanized Coating Designation: G90.
    - b. Finishes for Surfaces Exposed to View: Mill phosphatized.
  - 4. Galvanealed Sheet Steel (FOR EXPOSED, PAINTED DUCTWORK): Comply with ASTM A653-09; hot dipped zinc iron coated steel, annealed, coating designation "A" (A60, A40)
  - 5. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
    - a. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
  - 6. 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.
- B. Manufactured Ductwork and Fittings:
  - 1. Manufacture in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- C. Fabrication:
  - 1. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
  - 2. Provide turning vanes in all mitered elbows.
  - 3. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes of perforated metal with glass fiber insulation.
  - 4. T's, bends, and elbows: construct according to SMACNA (DCS).
  - 5. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA (DCS).
  - 6. Fabricate continuously welded round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Joints shall be minimum 4 inch cemented slip joint, brazed or electric welded. Prime coat welded joints.
  - 7. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install, support, and seal ducts in accordance with SMACNA (DCS).
- B. Install products following the manufacturer's instructions.
- C. Comply with safety standards NFPA 90A and NFPA 90B.

- D. 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.
- E. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- F. Install round ducts in maximum practical lengths.
- G. Install ducts with fewest possible joints.
- H. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- I. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- J. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- K. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- L. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."
- N. During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering the ductwork system.
- O. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- P. Duct sizes indicated are precise inside dimensions. For lined ducts, maintain sizes inside lining.
- Q. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with a crimp in the direction of airflow.
- R. Use double nuts and lock washers on threaded rod supports.

### **3.02 HANGERS AND SUPPORT INSTALLATION**

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  - 1. Where practical, install concrete inserts before placing concrete.
  - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
  - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
  - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.

- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

### **3.03 INSTALLATION OF EXPOSED DUCTWORK**

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

**END OF SECTION**

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**SECTION 23 5100  
BREECHINGS, CHIMNEYS, AND STACKS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Double wall metal stacks.

**1.02 REFERENCE STANDARDS**

- A. NFPA 54 - National Fuel Gas Code; 2021.
- B. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances; 2024.
- C. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- D. UL 103 - Factory-Built Chimneys for Residential Type and Building Heating Appliances; Current Edition, Including All Revisions.

**1.03 SUBMITTALS**

- A. Contractor shall provide submittals for equipment listed herein. Refer to Division 01 - General Requirements for submittal procedures.
- B. Product Data: Provide data indicating factory built chimneys, including dimensional details of components and flue caps, dimensions and weights, electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate general construction, dimensions, weights, support and layout of breechings. Submit layout drawings indicating plan view and elevations.

**PART 2 PRODUCTS**

**2.01 BREECHINGS, CHIMNEYS, AND STACKS - GENERAL REQUIREMENTS**

- A. Regulatory Requirements:
  - 1. Comply with applicable codes for installation of natural gas burning appliances and equipment.
  - 2. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

**2.02 DOUBLE WALL METAL STACKS**

- A. Manufacturers:
  - 1. AMPCO: [www.ampcostacks.com/#sle](http://www.ampcostacks.com/#sle).
  - 2. Selkirk Corporation: [www.selkirkcommercial.com/#sle](http://www.selkirkcommercial.com/#sle).
  - 3. DuraVent: [www.duravent.com](http://www.duravent.com)
  - 4. Metal-Fab, Inc.: [www.mtlfab.com](http://www.mtlfab.com)
  - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Provide double-wall metal stacks, tested to UL 103 and UL listed with positive pressure rating for use with building heating equipment; comply with NFPA 211.
- C. Fabricate with 1 inch minimum air space between walls and construct inner liner of AL29-4C stainless steel and outer jacket of 304 stainless steel.
  - 1. Protect aluminized steel surfaces exposed to elements with minimum of one base coat of primer and one finish coat of corrosion-resistant paint suitable for outer jacket skin temperatures of application.
- D. Design, fabricate, and install gastight to prevent products of combustion from leaking into building.
  - 1. Securely connect inner joints, and seal with factory-supplied overlapping V-bands and appropriate sealant in accordance with manufacturer's instructions.
  - 2. Design system to compensate for flue-gas-induced thermal expansion.
- E. Accessories, UL Labeled:

1. Ventilated Roof Thimble: Consists of roof penetration, vent flashing with spacers, and storm collar.
2. Rain/Stack Cap: Consists of conical rainshield with inverted cone for partial rain protection with low flow resistance.

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NFPA 54
- C. Rigidly support breechings from building structure with suitable ties, braces, hangers and anchors to hold to shape and prevent buckling. Support vertical breechings, chimneys, and stacks at 12-foot spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA (DCS) for equivalent duct support configuration and size.
- D. Pitch breechings for condensing equipment with positive slope up from fuel-fired equipment to chimney or stack. Provide low point drains at equipment and at any elbows along routing.
- E. Assemble and install stack sections in accordance with NFPA 82, UL Listings, and industry practices. Join sections with acid-resistant joint cement. Connect base section to foundation using anchor lugs.
- F. Level and plumb chimney and stacks.
- G. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of breechings, breeching insulation, chimneys, or stacks.

#### **3.02 SCHEDULES**

- A. Breechings, Chimneys and Stacks.
  1. Condensing Boiler and/or Water Heater: Double Wall Metal Stack

**END OF SECTION**

**SECTION 23 5216  
CONDENSING BOILERS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Manufactured units.
- B. Boiler construction.
- C. Boiler trim.
- D. Fuel burning system.
- E. Factory installed controls.

**1.02 RELATED REQUIREMENTS**

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 23 2114 - Hydronic Specialties.
- C. Section 23 2123 - Hydronic Pumps.
- D. Section 23 2500 - HVAC Water Treatment.
- E. Section 23 5100 - Breechings, Chimneys, and Stacks.
- F. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

**1.03 REFERENCE STANDARDS**

- A. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); Current Edition.
- B. ANSI Z21.13 - American National Standard for Gas-Fired Low-Pressure Steam and Hot Water Boilers; 2022.
- C. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. ASHRAE Std 135 - A Data Communication Protocol for Building Automation and Control Networks; 2020, with Errata (2023).
- E. ASME BPVC-IV - Boiler and Pressure Vessel Code, Section IV - Rules for Construction of Heating Boilers; 2023.
- F. NBBI Manufacturer and Repair Directory - The National Board of Boiler and Pressure Vessel Inspectors (NBBI); Current Edition.
- G. NFPA 54 - National Fuel Gas Code; 2021.
- H. SCAQMD 1146.1 - Emissions of Oxides of Nitrogen from Small Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters; 1990, with Amendment (2018).

**1.04 SUBMITTALS**

- A. Contractor shall provide submittals for equipment listed herein. Refer to Division 01 - General Requirements for submittal procedures.
- B. Product Data: Provide data indicating general assembly, components, controls, safety controls, and wiring diagrams with electrical characteristics and connection requirements, and service connections.
- C. Manufacturer's Field Reports: Burner manifold gas pressure, percent carbon monoxide (CO), percent oxygen (O), percent excess air, flue gas temperature at outlet, ambient temperature, net stack temperature, percent stack loss, percent combustion efficiency, and heat output.

**1.05 WARRANTY**

- A. See Section 01 7800 - Closeout Submittals for additional warranty requirements.
- B. Provide a five year warranty to include coverage for heat exchanger.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Natural Gas, Propane, or Combination Natural Gas/Propane for Indoor Applications:
  - 1. Aerco International, Inc : [www.aerco.com](http://www.aerco.com)
  - 2. Other manufacturers by voluntary alternate.
  - 3. Substitutions: See Section 01 6000 - Product Requirements.

### **2.02 MANUFACTURED UNITS**

- A. Factory assembled, factory fire-tested, self-contained, readily transported unit ready for automatic operation except for connection of water, fuel, electrical, and vent services.
- B. Unit: Metal membrane wall, water or fire tube, condensing boiler on integral structural steel frame base with integral fuel burning system, firing controls, boiler trim, insulation, and removable jacket, suitable for indoor application.

### **2.03 BOILER CONSTRUCTION**

- A. Comply with the minimum requirements of ASME BPVC-IV and ANSI Z21.13 for construction of boilers.
- B. Assembly to bear the ASME "H" stamp and comply with the efficiency requirements of the latest edition of ASHRAE Std 90.1 I-P.
- C. Required Directory Listings:
  - 1. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); current edition at [www.ahrinet.org](http://www.ahrinet.org).
  - 2. NBBI Manufacturer and Repair Directory - The National Board of Boiler and Pressure Vessel Inspectors (NBBI); current edition at [www.nationalboard.org](http://www.nationalboard.org).
- D. Heat Exchanger: Construct with materials that are impervious to corrosion where subject to contact with corrosive condensables.
- E. Provide adequate tappings, observation ports, removable panels, and access doors for entry, cleaning, and inspection.
- F. Insulate casing with insulation material, protected and covered by heavy-gauge metal jacket.
- G. Factory apply boiler base and other components, that are subject to corrosion, with durable, acrylic, powder coated, painted, or weather-proofed finish.

### **2.04 BOILER TRIM**

- A. ASME rated pressure relief valve.
- B. Flow switch.
- C. Electronic Low Water Cut-off: Complete with test light and manual reset button to automatically prevent firing operation whenever boiler water falls below safe level.
- D. Temperature and pressure gauge.
- E. Pressure Switches:
  - 1. High gas pressure.
  - 2. Low gas pressure.
  - 3. Air pressure.
- F. Manual reset high limit.
- G. Condensate neutralizer.
- H. Motorized boiler isolation valve (field installed) controlled by the boiler.

### **2.05 FUEL BURNING SYSTEM**

- A. Provide forced draft automatic burner, integral to boiler, designed to burn natural gas, and maintain fuel-air ratios automatically.
  - 1. Blower Design: Statically and dynamically balanced to supply combustion air; direct connected to motor.

2. Forced Draft Design: Mixes combustion air and gas to achieve 90 percent combustion efficiency.
  3. Combustion Air Filter: Protects fuel burning system from debris.
- B. Gas Train: Plug valve, safety gas valve, gas-air ratio control valve, and pressure regulator controls air and gas mixture.
- C. Emission of Oxides of Nitrogen Requirements: Comply with SCAQMD 1146.1 for natural gas fired system, as applicable.
- D. Intakes: Combustion air intake capable of accepting free mechanical room air or direct outside air through a sealed intake pipe.

## **2.06 FACTORY INSTALLED CONTROLS**

- A. Option for internal or external (0-10) VDC control.
- B. Temperature Controls:
1. Automatic reset type to control fuel burning system on-off and firing rate to maintain temperature.
  2. Manual reset type to control fuel burning system to prevent boiler water temperature from exceeding safe system water temperature.
  3. Low-fire start time delay relay.
- C. Electronic PI setpoint/modulation control system.
- D. Microprocessor-based, fuel/air mixing controls.
- E. BAS, SCADA, or other Integrated Automation Link: ASHRAE Std 135 BACnet MS/TP.
1. External Point Mapping: Provide mapping table for each parameter included in the local visual interface with software-toggle flag to allow reduced mapping of available points.
- F. O<sub>2</sub> trim system - Each boiler shall be equipped with an advanced O<sub>2</sub>-trim system for condensing boiler applications. The O<sub>2</sub> sensor shall be installed through the unit's burner plate and measure the oxygen content directly within the unit's combustion chamber. The system shall utilize a low cost reliable automotive grade O<sub>2</sub> sensor that measures and monitors the oxygen content of the exhaust gases. The system shall adjust the blower speed to maintain optimal air-fuel ratios in the event of any site condition changes (air density, gas pressure, BTU content, etc.). Output of O<sub>2</sub> information shall be displayed on the boiler control panel. The system shall have the following capabilities:
1. Self Diagnostics
    - a. System Status and Error Messages
    - b. When excessive trimming is occurring
    - c. When O<sub>2</sub> sensor has fallen out of calibration
  2. Adjustable parameter settings
    - a. O<sub>2</sub> target and range to meet site requirements
    - b. Schedule daily or weekly self diagnostics

## **PART 3 EXECUTION**

### **3.01 FACTORY AUTHORIZED START-UP**

- A. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct start-up as recommended by the manufacturer to secure and maintain all warranties.

### **3.02 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Install boiler and provide connection of natural gas service in accordance with requirements of NFPA 54 and applicable codes.
- C. Install boiler on concrete housekeeping base, sized minimum of 4 inches larger than boiler base in accordance with Section 03 3000.
- D. Coordinate provisions for water treatment in accordance with Section 23 2500.

- E. Pipe relief valves to nearest floor drain.
- F. Pipe cooled condensate produced by the combustion process from the boiler condensate connection and/or flue stack with suitable piping material to neutralizer prior to discharging into nearest floor drain.

### **3.03 CLOSEOUT ACTIVITIES**

- A. Demonstrate proper operation of equipment to Owner's designated representative.
- B. CSD-1 required reporting: Complete CSD-1 boiler analysis and inspection as required by Michigan boiler divisions. Provide completed forms to authority having jurisdiction and owner.
- C. Training: Train Owner's personnel on operation and maintenance of system.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of two hours of training.
  - 3. Instructor: Manufacturer's training personnel.
  - 4. Location: At project site.

**END OF SECTION**

**SECTION 26 0005  
BASIC ELECTRICAL REQUIREMENTS**

**PART 1 GENERAL**

**1.01 RELATED DOCUMENTS**

- A. This section applies to all sections of Division 26 and Division 28.
- B. Drawings and general provisions of the contract, including Division 00 and Division 01 specification sections, apply to work of this section.
- C. Provide all items, articles, materials, operations or methods listed, mentioned or scheduled on drawings and/or herein, including all labor, materials, equipment and incidentals necessary and required for their completion.
- D. The items in this section are supplementary to the requirements set forth in other portions of the specifications as indicated under Item "A" above.

**1.02 DRAWINGS**

- A. The drawings show the location and general arrangement of equipment, electrical systems and related items. They shall be followed as closely as elements of the construction will permit.
- B. Examine the drawings of other trades and verify the conditions governing the work on the job site. Arrange work accordingly, providing such fittings, conduit, junction boxes and accessories as may be required to meet such conditions.
- C. Deviations from the drawings, with the exception of minor changes in routing and other such incidental changes that do not affect the functioning or serviceability of the systems, shall not be made without the written approval of the Architect/Engineer.
- D. The architectural and structural drawings take precedence in all matters pertaining to the building structure, mechanical drawings in all matters pertaining to mechanical trades and electrical drawings in all matters pertaining to electrical trades. Where there are conflicts or differences between the drawings for the various trades, report such conflicts or differences to the Architect/Engineer for resolution.

**1.03 INSPECTION OF SITE**

- A. Visit the site, examine and verify the conditions under which the work must be conducted before submitting proposal.
- B. The submitting of a proposal implies that the contractor has visited the site and understands the conditions under which the work must be conducted.

**1.04 TEMPORARY FACILITIES**

- A. Provide and remove upon completion of the project, in accordance with the general conditions, a complete temporary electrical and telephone service during construction.

**1.05 ALTERNATES AND SUBSTITUTIONS**

- A. Refer to Division 01 - General Requirements for procedures.

**1.06 GUARANTEE**

- A. Contractor guarantees that the installation is free from defects and agrees to replace or repair, any part of this installation which becomes defective within a period of one year following final acceptance, unless noted otherwise, provided that such failure is due to defects in the equipment, material or installation or to follow the specifications and drawings. File with the Owner any and all guarantees from the equipment manufacturers.

**1.07 CODES, PERMITS AND FEES**

- A. Unless otherwise indicated, all required permits, licenses, inspections, approvals and fees for electrical work shall be secured and paid for by the contractor. All work shall conform to all applicable codes, rules and regulations. Applicable publications listed in all sections of Division 26 shall be the latest issue, unless otherwise noted.

- B. Rules of local utility companies shall be complied with. Check with the utility company supplying service to the installation and determine all devices including, but not limited to, all current and potential transformers, meter boxes, C.T. cabinets and meters which will be required and include the cost of all such items in proposal.
- C. All work shall be executed in accordance with the rules and regulations set forth in local and state codes. Prepare any detailed drawings or diagrams which may be required by the governing authorities. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern.

#### **1.08 STANDARDS OF MATERIAL AND WORKMANSHIP:**

- A. All materials shall be new, unless noted otherwise. The electrical and physical properties of all materials, and the design, performance characteristics, and methods of construction of all items of equipment, shall be in accordance with the latest issue of the various, applicable standard specifications of the following recognized authorities:
  - 1. A.N.S.I. - American National Standards Institute
  - 2. A.S.T.M. - American Society for Testing Materials
  - 3. I.C.E.A. - Insulated Cable Engineers Association
  - 4. I.E.E.E. - Institute of Electrical and Electronics Engineers
  - 5. N.E.C. - National Electrical Code (NFPA 70)
  - 6. N.E.C.A. - National Electrical Contractors Association
  - 7. N.E.M.A. - National Electrical Manufacturer's Association
  - 8. N.F.P.A. - National Fire Protection Association
  - 9. U.L. - Underwriters Laboratories, Inc.
- B. Perform all work in a first class and workmanlike manner, in accordance with the latest accepted standards and practices for the Trades involved.
- C. All equipment of the same or similar systems shall be by the same manufacturer.

#### **1.09 RECORD DRAWINGS**

- A. Refer to Division 01 - General Requirements for procedures. All literature shall be furnished in accordance with requirements listed in Division 01.
- B. Contractor shall provide the following record drawings as part of the Project closeout document process:
  - 1. Contract Documents, specifications and submittals, indicating "As-Built" conditions and actual products selected for use.
  - 2. Product and Maintenance manuals for all equipment listed within this specification manual and in Contract Documents. Provide with parts lists as applicable.

#### **1.10 SUBMITTALS**

- A. Refer to Division 01 - General Requirements for procedures.
- B. Contractor shall provide submittals where items are referred to by symbolic designation on the drawings. All submittals shall bear the same designation (light fixtures, wiring devices, etc.). Refer to other sections of the electrical specifications for additional requirements.
- C. Engineer WILL NOT REVIEW:
  - 1. Submittals not specified.
  - 2. Submittals which do not indicate optional equipment being provided.
  - 3. Submittals not reviewed by Contractor; including Contractor stamp with signature comments.
  - 4. Submittals made after work is delivered to site and/or installed.
  - 5. Submittal resubmissions unless resubmission is required by Architect/Engineer.

#### **1.11 MANUFACTURERS LISTED**

- A. The listing of specific manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.



- B. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer five (5) days prior to bid date.

#### **1.12 USE OF EQUIPMENT**

- A. The use of any equipment, or any part thereof for purposes other than testing even with the Owner's consent, shall not be construed to be an acceptance of the work on the part of the Owner, nor be construed to obligate the Owner in any way to accept improper work or defective materials.
- B. Do not use Owner's light fixtures for temporary lighting except as allowed and directed by the Owner.

### **PART 2 PRODUCTS - NOT USED**

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION OF EQUIPMENT**

- A. Install all equipment in strict accordance with all directions and recommendations furnished by the manufacturer. Where such directions are in conflict with the drawings and specifications, report such conflicts to the Architect/Engineer for resolution.
- B. Equipment location shall be as close as practical to locations shown on the drawings.
- C. Working clearances shall not be less than specified in NFPA 70 (National Electric Code).

#### **3.02 COORDINATION**

- A. Install work to avoid interference with work of other trades including, but not limited to, architectural and mechanical trades. Remove and relocate any work that causes an interference at Contractor's expense. Disputes regarding the cause of an interference will be resolved by the Construction Manager or Architect/Engineer.

#### **3.03 CUTTING, PATCHING AND DAMAGE TO OTHER WORK**

- A. Refer to Division 01 - General Requirements and Division 02 - Existing Conditions.
- B. All cutting, patching and repair work shall be performed by the contractor through approved, qualified subcontractors. Contractor shall include full cost of same in bid.

#### **3.04 EXCAVATION AND BACKFILLING**

- A. Provide all excavation, trenching, tunneling, dewatering and backfilling required for the electrical work. Coordinate the work with other excavating and backfilling in the same area.
- B. Where conduit is installed less than 30" below the surface of pavement, provide concrete encasement, 4" minimum coverage, all around or as shown on the electrical drawings.
- C. Backfill all excavations inside building, under drives and parking areas with well-tamped granular material. Backfill all excavations under wall footings with lean mix concrete up to underside of footings and extend concrete within excavation a minimum of four (4) feet each side of footing. Granular backfill shall be placed in layers not more than 8 inches in thickness, 95 percent compaction throughout with approved compaction equipment. Tamp, roll as required. Excavated material shall not be used.
- D. Backfill outside building with granular material to a height 12 inches over top of pipe compacted to 95 percent compaction as specified above. Backfill remainder of excavation with unfrozen, excavated material in such a way to prevent settling. Tamp, roll as required.

#### **3.05 EQUIPMENT FOUNDATION AND SUPPORTS**

- A. Shall be as required or as shown on plans or specified.
- B. Provide concrete house keeping bases 4" above finished floor, with leveling channels, where noted, for floor-mounted equipment. Coordinate requirements with Division 03 - Concrete.
- C. For equipment suspended from ceilings or walls, furnish and install all inserts, rods, structural steel frames, brackets and platforms required.

#### **3.06 EQUIPMENT CONNECTIONS**

- A. Make connections to equipment, motors, lighting fixtures, and other items included in the work in accordance with the approved shop drawings and rough-in measurements furnished by the manufacturers of the particular equipment furnished. All additional connections not shown on the drawings, but called out by the equipment manufacturer's shop drawings shall be provided.

### **3.07 ACCESS DOORS AND PANELS**

- A. Refer to Division 08 - Openings; Provide access doors in locations as required per N.E.C. Coordinate locations with architectural trades.

### **3.08 CLEANING**

- A. Refer to Division 01 - General Requirements; All equipment shall be cleaned as frequently as necessary through the construction process and again prior to project completion.
- B. Final cleanup shall include, but not be limited to, washing of fixture lenses or louvers, switchboards, substations, motor control centers, panels, etc. Fixture reflectors and lenses or louvers shall be left with no water marks or cleaning streaks.

### **3.09 DELIVERY, STORAGE AND PROTECTION OF EQUIPMENT AND MATERIALS**

- A. Refer to Division 01 - General Requirements; All equipment and materials shall be delivered, stored and secured per manufacturer's recommendations.
- B. On-site storage shall be coordinated with Construction Manager and be performed in a manner as to avoid damage, deterioration and loss.

### **3.10 DRAWINGS AND MEASUREMENTS**

- A. Electrical drawings are not intended to be scaled for rough-in measurements nor to serve as submittals. Field measurements necessary for ordering materials and fitting the installation to the building construction and arrangement shall be taken by the Contractor.

**END OF SECTION**

**SECTION 26 0505  
SELECTIVE DEMOLITION FOR ELECTRICAL**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Electrical demolition and extension of existing electrical work.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements
- B. Division 02 - Existing Conditions: Demolition, cleaning and disposal requirements.
- C. Section 26 0005 - Basic Electrical Requirements.

**PART 2 PRODUCTS**

**2.01 MATERIALS AND EQUIPMENT**

- A. Materials and equipment for patching and extending work: As specified in individual sections.

**PART 3 EXECUTION**

**3.01 EXAMINATION**

- A. Verify that abandoned wiring and equipment serve only abandoned facilities.
- B. Demolition drawings are based on casual field observation and existing record documents.
- C. Beginning of demolition means installer accepts existing conditions.

**3.02 PREPARATION**

- A. Disconnect electrical systems in walls, floors, and ceilings to be removed.
- B. Coordinate utility service outages with utility company.
- C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
- D. Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Minimize outage duration.
  - 1. Obtain permission from Owner at least 24 hours before partially or completely disabling system.
  - 2. Make temporary connections to maintain service in areas adjacent to work area.
- E. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Minimize outage duration.
  - 1. Notify Owner before partially or completely disabling system.
  - 2. Notify local fire service.
  - 3. Make notifications at least 24 hours in advance.
  - 4. Make temporary connections to maintain service in areas adjacent to work area.

**3.03 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK**

- A. Perform work for removal and disposal of equipment and materials containing toxic substances regulated under the Federal Toxic Substances Control Act (TSCA) in accordance with applicable federal, state, and local regulations. Applicable equipment and materials include, but are not limited to:
  - 1. PCB-containing electrical equipment, including transformers, capacitors, and switches.
  - 2. PCB- and DEHP-containing lighting ballasts.
  - 3. Mercury-containing lamps and tubes, including fluorescent lamps, high intensity discharge (HID), arc lamps, ultra-violet, high pressure sodium, mercury vapor, ignitron tubes, neon, and incandescent.
- B. Remove, relocate, and extend existing installations to accommodate new construction.
- C. Remove abandoned wiring to source of supply.

- D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
- E. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets that are not removed.
- F. Disconnect and remove abandoned panelboards and distribution equipment.
- G. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.
- H. Repair adjacent construction and finishes damaged during demolition and extension work.
- I. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.

### **3.04 CLEANING AND REPAIR**

- A. See Division 01 - General Requirements.
- B. Clean and repair existing materials and equipment that remain or that are to be reused.
- C. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.
- D. Luminaires: Remove existing luminaires for cleaning. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace lamps, ballasts and broken electrical parts.

**END OF SECTION**

**SECTION 26 0519**  
**LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Single conductor building wire.
- B. Metal-clad cable.
- C. Mineral-Insultated cable.
- D. Wiring connectors.
- E. Electrical tape.
- F. Heat shrink tubing.
- G. Oxide inhibiting compound.
- H. Wire pulling lubricant.
- I. Cable ties.
- J. Firestop sleeves.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements.
- B. Division 02 - Existing Conditions: Demolition, cleaning and disposal requirements, cutting and patching requirements, and repairs.
- C. Division 07 - Thermal and Moisture Protection: Firestopping.
- D. Section 26 0005 - Basic Electrical Requirements.
- E. Section 26 0505 - Selective Demolition for Electrical: Disconnection, removal, and/or extension of existing electrical conductors and cables.
- F. Section 26 0526 - Grounding and Bonding for Electrical Systems: Additional requirements for grounding conductors and grounding connectors.
- G. Section 26 0536 - Cable Trays for Electrical Systems: Additional installation requirements for cables installed in cable tray systems.
- H. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- I. Section 28 4600 - Fire Detection and Alarm: Fire alarm system conductors and cables.
- J. Division 31 - Earthwork: Excavating, bedding, and backfilling.

**1.03 REFERENCE STANDARDS**

- A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire; 2013 (Reapproved 2018).
- B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; 2011 (Reapproved 2017).
- C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes; 2010, with Editorial Revision (2020).
- D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation; 2004 (Reapproved 2020).
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- F. NECA 120 - Standard for Installing Armored Cable (AC) and Type Metal-Clad (MC) Cable; 2018.
- G. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy; 2021.
- H. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems; 2021.

- I. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- J. UL 44 - Thermoset-Insulated Wires and Cables; Current Edition, Including All Revisions.
- K. UL 83 - Thermoplastic-Insulated Wires and Cables; Current Edition, Including All Revisions.
- L. UL 486A-486B - Wire Connectors; Current Edition, Including All Revisions.
- M. UL 486C - Splicing Wire Connectors; Current Edition, Including All Revisions.
- N. UL 486D - Sealed Wire Connector Systems; Current Edition, Including All Revisions.
- O. UL 1569 - Metal-Clad Cables; Current Edition, Including All Revisions.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
  - 2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
  - 3. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

#### **1.05 SUBMITTALS**

- A. Contractor shall provide submittals for equipment listed herein. Refer to Division 01 for submittal procedures.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

#### **1.07 FIELD CONDITIONS**

- A. Do not install or otherwise handle thermoplastic-insulated conductors at temperatures lower than 14 degrees F, unless otherwise permitted by manufacturer's instructions. When installation below this temperature is unavoidable, notify Architect and obtain direction before proceeding with work.

### **PART 2 PRODUCTS**

#### **2.01 CONDUCTOR AND CABLE APPLICATIONS**

- A. Do not use conductors and cables for applications other than as permitted by NFPA 70 and product listing.
- B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.
- C. Feeders provided for Emergency Power systems shall within a 2-hour rated raceway or enclosure and installed per NEC 700.11.
- D. Nonmetallic-sheathed cable is not permitted.
- E. Underground feeder and branch-circuit cable is not permitted.
- F. Service entrance cable is not permitted.
- G. Armored cable is not permitted.
- H. Metal-clad cable is permitted only as follows:
  - 1. Where not otherwise restricted, may be used:

- a. Where concealed above accessible ceilings for final connections from junction boxes to luminaires.
    - 1) Maximum Length: 6 feet.
  - b. Where concealed in hollow stud walls, above accessible ceilings, and under raised floors for branch circuits up to 20 A.
- I. Mineral-Insulated cable is permitted only as follows:
- 1. Where not otherwise restricted, may be used:
    - a. For feeders from Generator to Fire Pump.
- J. Manufactured wiring systems are not permitted.

## **2.02 CONDUCTOR AND CABLE GENERAL REQUIREMENTS**

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.
- D. Comply with NEMA WC 70.
- E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
- F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
- G. Conductor Material:
  - 1. Provide copper conductors only. Aluminum conductors are not acceptable for this project. Conductor sizes indicated are based on copper.
  - 2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
  - 3. Tinned Copper Conductors: Comply with ASTM B33.
- H. Minimum Conductor Size:
  - 1. Branch Circuits: 12 AWG.
    - a. Exceptions:
      - 1) 20 A, 120 V circuits longer than 75 feet: 10 AWG, for voltage drop.
      - 2) 20 A, 120 V circuits longer than 150 feet: 8 AWG, for voltage drop.
      - 3) 20 A, 277 V circuits longer than 150 feet: 10 AWG, for voltage drop.
- I. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- J. Conductor Color Coding:
  - 1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
  - 2. Color Coding Method: Integrally colored insulation.
  - 3. Color Code:
    - a. 480Y/277 V, 3 Phase, 4 Wire System:
      - 1) Phase A: Brown.
      - 2) Phase B: Orange.
      - 3) Phase C: Yellow.
      - 4) Neutral/Grounded: Gray.
    - b. 208Y/120 V, 3 Phase, 4 Wire System:
      - 1) Phase A: Black.
      - 2) Phase B: Red.
      - 3) Phase C: Blue.
      - 4) Neutral/Grounded: White.
    - c. Equipment Ground, All Systems: Green.

- d. For modifications or additions to existing wiring systems, comply with existing color code when existing code complies with NFPA 70 and is approved by the authority having jurisdiction.

### **2.03 SINGLE CONDUCTOR BUILDING WIRE**

- A. Manufacturers:
  - 1. Copper Building Wire:
    - a. Cerro Wire LLC: [www.cerrowire.com](http://www.cerrowire.com).
    - b. Encore Wire Corporation: [www.encorewire.com](http://www.encorewire.com).
    - c. General Cable Technologies Corporation: [www.generalcable.com](http://www.generalcable.com).
    - d. Southwire Company: [www.southwire.com](http://www.southwire.com).
- B. Description: Single conductor insulated wire.
- C. Conductor Stranding:
  - 1. Feeders and Branch Circuits:
    - a. Size 10 AWG and Smaller: Stranded.
    - b. Size 8 AWG and Larger: Stranded.
- D. Insulation Voltage Rating: 600 V.
- E. Insulation:
  - 1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.

### **2.04 METAL-CLAD CABLE**

- A. Manufacturers:
  - 1. Cerro Wire LLC: [www.cerrowire.com](http://www.cerrowire.com).
  - 2. AFC Cable Systems Inc: [www.afcweb.com](http://www.afcweb.com).
  - 3. Encore Wire Corporation: [www.encorewire.com](http://www.encorewire.com).
  - 4. Southwire Company: [www.southwire.com](http://www.southwire.com).
- B. Description: NFPA 70, Type MC cable listed and labeled as complying with UL 1569, and listed for use in classified firestop systems to be used.
- C. Conductor Stranding:
  - 1. Size 10 AWG and Smaller: Stranded.
  - 2. Size 8 AWG and Larger: Stranded.
- D. Insulation Voltage Rating: 600 V.
- E. Insulation: Type THHN, THHN/THWN, or THHN/THWN-2.
- F. Provide oversized neutral conductors.
- G. Grounding: Full-size integral equipment grounding conductor.
- H. Armor: Steel, interlocked tape.

### **2.05 WIRING CONNECTORS**

- A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.
- B. Connectors for Grounding and Bonding: Comply with Section 26 0526.
- C. Wiring Connectors for Splices and Taps:
  - 1. Copper Conductors Size 8 AWG and Smaller: Use twist-on insulated spring connectors.
  - 2. Copper Conductors Size 6 AWG and Larger: Use mechanical connectors or compression connectors.
- D. Wiring Connectors for Terminations:
  - 1. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
  - 2. Provide compression adapters for connecting conductors to equipment furnished with mechanical lugs when only compression connectors are specified.



3. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.
4. Copper Conductors Size 8 AWG and Larger: Use mechanical connectors or compression connectors where connectors are required.
- E. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.
- F. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.
- G. Twist-on Insulated Spring Connectors: Rated 600 V, 221 degrees F for standard applications and 302 degrees F for high temperature applications; pre-filled with sealant and listed as complying with UL 486D for damp and wet locations.
- H. Mechanical Connectors: Provide bolted type or set-screw type.
- I. Compression Connectors: Provide circumferential type or hex type crimp configuration.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Verify that interior of building has been protected from weather.
- B. Verify that work likely to damage wire and cable has been completed.
- C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.
- D. Verify that field measurements are as indicated.
- E. Verify that conditions are satisfactory for installation prior to starting work.

#### **3.02 PREPARATION**

- A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

#### **3.03 INSTALLATION**

- A. Circuiting Requirements:
  1. Unless dimensioned, circuit routing indicated is diagrammatic.
  2. When circuit destination is indicated without specific routing, determine exact routing required.
  3. Arrange circuiting to minimize splices.
  4. Include circuit lengths required to install connected devices within 10 ft of location indicated.
  5. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
  6. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
  7. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as separate, combining them together in a single raceway is not permitted.
  8. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors among up to three single phase branch circuits of different phases installed in the same raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual branch circuit.
  9. Provide oversized neutral/grounded conductors where indicated and as specified below.
    - a. Provide 200 percent rated neutral for feeders fed from K-rated transformers.
    - b. Provide 200 percent rated neutral for feeders serving panelboards with 200 percent rated neutral bus.
- B. Install products in accordance with manufacturer's instructions.
- C. Perform work in accordance with NECA 1 (general workmanship).
- D. Install metal-clad cable (Type MC) in accordance with NECA 120.
- E. Installation in Raceway:

1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
  2. Pull all conductors and cables together into raceway at same time.
  3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
  4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.
- F. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.
- G. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
- H. Terminate cables using suitable fittings.
1. Metal-Clad Cable (Type MC):
    - a. Use listed fittings.
    - b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.
- I. Install conductors with a minimum of 12 inches of slack at each outlet.
- J. Where conductors are installed in enclosures for future termination by others, provide a minimum of 5 feet of slack.
- K. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.
- L. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.
- M. Make wiring connections using specified wiring connectors.
1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
  2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
  3. Do not remove conductor strands to facilitate insertion into connector.
  4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminants. Do not use wire brush on plated connector surfaces.
  5. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
  6. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- N. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
- O. Insulate ends of spare conductors using vinyl insulating electrical tape.
- P. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Division 07.
- Q. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

### **3.04 FIELD QUALITY CONTROL**

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Perform inspections and tests listed in NETA ATS, Section 7.3.2. The insulation resistance test is required for all conductors. The resistance test for parallel conductors listed as optional is not required.

- C. Correct deficiencies and replace damaged or defective conductors and cables.

**END OF SECTION**

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**SECTION 26 0526**  
**GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Grounding and bonding requirements.
- B. Conductors for grounding and bonding.
- C. Connectors for grounding and bonding.
- D. Ground bars.
- E. Ground rod electrodes.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements
- B. Division 02 - Existing Conditions: Demolition, cleaning and disposal requirements, cutting and patching requirements, repairs.
- C. Section 26 0005 - Basic Electrical Requirements
- D. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables: Additional requirements for conductors for grounding and bonding, including conductor color coding.
- E. Section 26 0536 - Cable Trays for Electrical Systems: Additional grounding and bonding requirements for cable tray systems.
- F. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- G. Section 26 5600 - Exterior Lighting: Additional grounding and bonding requirements for pole-mounted luminaires.
- H. Division 31 - Earthwork: Excavating, trenching and fill.

**1.03 REFERENCE STANDARDS**

- A. IEEE 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System; 2012.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- C. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems; 2021.
- D. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. UL 467 - Grounding and Bonding Equipment; Current Edition, Including All Revisions.

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Verify exact locations of underground metal water service pipe entrances to building.
  - 2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.
  - 3. Notify Strategic Energy Solutions, Inc. of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not install ground rod electrodes until final backfill and compaction is complete.

**1.05 SUBMITTALS**

- A. Contractor shall provide submittals for equipment listed herein. Refer to Division 01 for submittal procedures.
- B. Project Record Documents: Record actual locations of grounding electrode system components and connections.

## **PART 2 PRODUCTS**

### **2.01 GROUNDING AND BONDING REQUIREMENTS**

- A. Existing Work: Where existing grounding and bonding system components are indicated to be reused, they may be reused only where they are free from corrosion, integrity and continuity are verified, and where acceptable to the authority having jurisdiction.
- B. Do not use products for applications other than as permitted by NFPA 70 and product listing.
- C. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
- D. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- E. Grounding System Resistance:
  - 1. Achieve specified grounding system resistance under normally dry conditions unless otherwise approved by Architect. Precipitation within the previous 48 hours does not constitute normally dry conditions.
  - 2. Grounding Electrode System: Not greater than 5 ohms to ground, when tested according to IEEE 81 using "fall-of-potential" method.
  - 3. Between Grounding Electrode System and Major Electrical Equipment Frames, System Neutral, and Derived Neutral Points: Not greater than 0.5 ohms, when tested using "point-to-point" methods.
- F. Grounding Electrode System:
  - 1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
    - a. Provide continuous grounding electrode conductors without splice or joint.
    - b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
  - 2. Provide additional ground electrode(s) as required to achieve specified grounding electrode system resistance.
- G. Bonding and Equipment Grounding:
  - 1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
  - 2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
  - 3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
  - 4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
  - 5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
  - 6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
  - 7. Provide bonding for interior metal piping systems in accordance with NFPA 70. This includes, but is not limited to:
    - a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.
    - b. Metal gas piping.
  - 8. Provide bonding for metal building frame.
  - 9. Provide bonding for metal siding not effectively bonded through attachment to metal building frame.

- H. Cable Tray Systems: Also comply with Section 26 0536.
- I. Pole-Mounted Luminaires: Also comply with Section 26 5600.

## **2.02 GROUNDING AND BONDING COMPONENTS**

- A. General Requirements:
  - 1. Provide products listed, classified, and labeled as suitable for the purpose intended.
  - 2. Provide products listed and labeled as complying with UL 467 where applicable.
- B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 26 0526:
  - 1. Use insulated copper conductors unless otherwise indicated.
    - a. Exceptions:
      - 1) Use bare copper conductors where installed underground in direct contact with earth.
      - 2) Use bare copper conductors where directly encased in concrete (not in raceway).
- C. Connectors for Grounding and Bonding:
  - 1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
  - 2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
  - 3. Unless otherwise indicated, use mechanical connectors, compression connectors, or exothermic welded connections for accessible connections.
  - 4. Manufacturers - Mechanical and Compression Connectors:
    - a. Advanced Lightning Technology (ALT): [www.altfab.com](http://www.altfab.com)
    - b. Burndy LLC: [www.burndy.com](http://www.burndy.com)
    - c. Harger Lightning & Grounding: [www.harger.com](http://www.harger.com)
    - d. nVent ERICO; \_\_\_\_\_: [www.nvent.com/](http://www.nvent.com/)
    - e. Thomas & Betts Corporation: [www.tnb.com](http://www.tnb.com)
  - 5. Manufacturers - Exothermic Welded Connections:
    - a. Burndy LLC: [www.burndy.com](http://www.burndy.com)
    - b. nVent ERICO; Cadweld: [www.nvent.com](http://www.nvent.com)
    - c. thermOweld, subsidiary of Continental Industries; division of Burndy LLC: [www.thermoweld.com](http://www.thermoweld.com)

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that work likely to damage grounding and bonding system components has been completed.
- B. Verify that field measurements are as indicated.
- C. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Make grounding and bonding connections using specified connectors.
  - 1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
  - 2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
  - 3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
  - 4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.

- 5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- D. Identify grounding and bonding system components in accordance with Section 26 0553.

**3.03 FIELD QUALITY CONTROL**

- A. Inspect and test in accordance with NETA ATS except Section 4.
- B. Perform inspections and tests listed in NETA ATS, Section 7.13.
- C. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
- D. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.

**END OF SECTION**



**SECTION 26 0529  
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Support and attachment requirements and components for equipment, conduit, cable, boxes, and other electrical work.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements
- B. Division 02 - Existing Conditions: Demolition, cleaning and disposal requirements, and cutting and patching requirements.
- C. Division 03 - Concrete: Concrete equipment pads.
- D. Section 26 0005 - Basic Electrical Requirements
- E. Section 26 0533.13 - Conduit for Electrical Systems: Additional support and attachment requirements for conduits.
- F. Section 26 0536 - Cable Trays for Electrical Systems: Additional support and attachment requirements for cable tray.
- G. Section 26 0533.16 - Boxes for Electrical Systems: Additional support and attachment requirements for boxes.
- H. Section 26 2513 - Low-Voltage Busways: Additional support and attachment requirements for busway.
- I. Section 26 5100 - Interior Lighting: Additional support and attachment requirements for interior luminaires.
- J. Section 26 5600 - Exterior Lighting: Additional support and attachment requirements for exterior luminaires.

**1.03 REFERENCE STANDARDS**

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2023.
- C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2023.
- D. MFMA-4 - Metal Framing Standards Publication; 2004.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. UL 5B - Strut-Type Channel Raceways and Fittings; Current Edition, Including All Revisions.

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate sizes and arrangement of supports and bases with actual equipment and components to be installed.
  - 2. Coordinate work to provide additional framing and materials required for installation.
  - 3. Coordinate compatibility of support and attachment components with mounting surfaces at installed locations.
  - 4. Coordinate arrangement of supports with ductwork, piping, equipment and other potential conflicts.
  - 5. Notify Architect of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

- B. Sequencing:
  - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Division 03.

### 1.05 QUALITY ASSURANCE

- A. Product Listing Organization Qualifications: Organization recognized by OSHA as Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

## PART 2 PRODUCTS

### 2.01 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
  - 1. Comply with the following. Where requirements differ, comply with most stringent.
    - a. NFPA 70.
    - b. Requirements of authorities having jurisdiction.
  - 2. Provide required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for complete installation of electrical work.
  - 3. Provide products listed, classified, and labeled as suitable for purpose intended, where applicable.
  - 4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
  - 5. Do not use products for applications other than as permitted by NFPA 70 and product listing.
  - 6. Steel Components: Use corrosion-resistant materials suitable for environment where installed.
    - a. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
    - b. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Conduit and Cable Supports: Straps and clamps suitable for conduit or cable to be supported.
  - 1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
  - 2. Conduit Clamps: Bolted type unless otherwise indicated.
- C. Outlet Box Supports: Hangers and brackets suitable for boxes to be supported.
  - 1. Manufacturers:
    - a. ABB: [www.electrification.us.abb.com](http://www.electrification.us.abb.com)
    - b. Eaton Corporation: [www.eaton.com](http://www.eaton.com)
    - c. Emerson Electric Co; O-Z/Gedney: [www.emerson.com](http://www.emerson.com)
    - d. HoldRite, a brand of Reliance Worldwide Corporation: [www.holdrite.com](http://www.holdrite.com)
    - e. nVent; Caddy: [www.nvent.com](http://www.nvent.com)
- D. Metal Channel/Strut Framing Systems:
  - 1. Manufacturers:
    - a. ABB: [www.electrification.us.abb.com/#sle](http://www.electrification.us.abb.com/#sle).
    - b. Atkore International Inc; Unistrut: [www.unistrut.us/#sle](http://www.unistrut.us/#sle).
    - c. Eaton Corporation: [www.eaton.com/#sle](http://www.eaton.com/#sle).
  - 2. Description: Factory-fabricated, continuous-slot, metal channel/strut and associated fittings, accessories, and hardware required for field assembly of supports.
  - 3. Comply with MFMA-4.
  - 4. Channel/Strut Used as Raceway, Where Indicated: Listed and labeled as complying with UL 5B.
- E. Hanger Rods: Threaded, zinc-plated steel unless otherwise indicated.
  - 1. Minimum Size, Unless Otherwise Indicated or Required:
    - a. Equipment Supports: 1/2-inch diameter.
    - b. Single Conduit up to 1-inch (27 mm) Trade Size: 1/4-inch diameter.

- c. Single Conduit Larger than 1-inch (27 mm) Trade Size: 3/8-inch diameter.
  - d. Trapeze Support for Multiple Conduits: 3/8-inch diameter.
  - e. Outlet Boxes: 1/4-inch diameter.
  - f. Luminaires: 1/4-inch diameter.
- F. Nonpenetrating Rooftop Supports for Low-Slope Roofs:
- 1. Manufacturers:
    - a. Atkore International Inc; Unistrut: [www.unistrut.us/#sle](http://www.unistrut.us/#sle).
    - b. Eaton Corporation: [www.eaton.com/#sle](http://www.eaton.com/#sle).
    - c. nVent; Caddy: [www.nvent.com/#sle](http://www.nvent.com/#sle).
    - d. PHP Systems/Design: [www.phpsd.com/#sle](http://www.phpsd.com/#sle).
  - 2. Description: Steel pedestals with thermoplastic or rubber bases that rest on top of roofing membrane, not requiring attachment to roof structure and not penetrating roofing assembly, with support fixtures as specified.
  - 3. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
  - 4. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports.
  - 5. Mounting Height: Provide minimum clearance of 6 inches under supported component to top of roofing.
- G. Anchors and Fasteners:
- 1. Manufacturers - Mechanical Anchors:
    - a. Dewalt: [anchors.dewalt.com](http://anchors.dewalt.com)
    - b. Hilti, Inc: [www.hilti.com](http://www.hilti.com)
    - c. ITW Red Head, a division of Illinois Tool Works, Inc: [www.itwredhead.com](http://www.itwredhead.com)
    - d. Simpson Strong-Tie Company Inc: [www.strongtie.com](http://www.strongtie.com)
  - 2. Unless otherwise indicated and where not otherwise restricted, use anchor and fastener types indicated for specified applications.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install hangers and supports in accordance with NECA 1.
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- D. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by Architect, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Equipment Support and Attachment:
  - 1. Use metal, fabricated supports or supports assembled from metal channel/strut to support equipment as required.
  - 2. Use metal channel/strut secured to studs to support equipment surface mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
  - 3. Use metal channel/strut to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
  - 4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 4 inch high concrete pad constructed in accordance with Division 03.
  - 5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- H. Conduit Support and Attachment: See Section 26 0533.13 for additional requirements.
- I. Cable Tray Support and Attachment: See Section 26 0536 for additional requirements.

- J. Box Support and Attachment: See Section 26 0533.16 for additional requirements.
- K. Busway Support and Attachment: See Section 26 2513 for additional requirements.
- L. Interior Luminaire Support and Attachment: See Section 26 5100 for additional requirements.
- M. Exterior Luminaire Support and Attachment: See Section 26 5600 for additional requirements.
- N. Secure fasteners in accordance with manufacturer's recommended torque settings.
- O. Remove temporary supports.
- P. Identify independent electrical component support wires above accessible ceilings, where permitted, with color distinguishable from ceiling support wires in accordance with NFPA 70.

### **3.02 FIELD QUALITY CONTROL**

- A. Inspect support and attachment components for damage and defects.
- B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- C. Correct deficiencies and replace damaged or defective support and attachment components.

**END OF SECTION**

**SECTION 26 0533.13  
CONDUIT FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Galvanized steel rigid metal conduit (RMC).
- B. Aluminum rigid metal conduit (RMC).
- C. Flexible metal conduit (FMC).
- D. Galvanized steel electrical metallic tubing (EMT).
- E. Aluminum electrical metallic tubing (EMT).
- F. Rigid polyvinyl chloride (PVC) conduit.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements.
- B. Division 02 - Existing Conditions: Demolition, cleaning and disposal requirements, cutting and patching requirements, and repairs.
- C. Division 03 - Concrete: Concrete encasement of conduits.
- D. Division 07 - Thermal and Moisture Protection: Firestopping.
- E. Section 26 0005 - Basic Electrical Requirements
- F. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables.
- G. Section 26 0526 - Grounding and Bonding for Electrical Systems.
  - 1. Includes additional requirements for fittings for grounding and bonding.
- H. Section 26 0529 - Hangers and Supports for Electrical Systems.
- I. Section 26 0533.16 - Boxes for Electrical Systems.
- J. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- K. Section 28 4600 - Fire Detection and Alarm: Fire alarm wiring in conduit.
- L. Division 31 - Earthwork: Excavating, trenching and fill.

**1.03 REFERENCE STANDARDS**

- A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC); 2020.
- B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S); 2020.
- C. ANSI C80.5 - American National Standard for Electrical Rigid Metal Conduit -- Aluminum (ERMC-A); 2020.
- D. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- E. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT); 2020.
- F. NECA 102 - Standard for Installing Aluminum Rigid Metal Conduit; 2004.
- G. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC); 2017.
- H. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2014.
- I. NEMA RN 1 - Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Metal Conduit and Intermediate Metal Conduit; 2018.
- J. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit; 2020.
- K. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing; 2021.
- L. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

- M. UL 1 - Flexible Metal Conduit; Current Edition, Including All Revisions.
- N. UL 6 - Electrical Rigid Metal Conduit-Steel; Current Edition, Including All Revisions.
- O. UL 6A - Electrical Rigid Metal Conduit-Aluminum, Red Brass, and Stainless Steel; Current Edition, Including All Revisions.
- P. UL 514B - Conduit, Tubing, and Cable Fittings; Current Edition, Including All Revisions.
- Q. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings; Current Edition, Including All Revisions.
- R. UL 797 - Electrical Metallic Tubing-Steel; Current Edition, Including All Revisions.
- S. UL 797A - Electrical Metallic Tubing - Aluminum and Stainless Steel; Current Edition, Including All Revisions.
- T. UL 2419 - Outline of Investigation for Electrically Conductive Corrosion Resistant Compounds; Current Edition, Including All Revisions.

## **PART 2 PRODUCTS**

### **2.01 CONDUIT APPLICATIONS**

- A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70, manufacturer's instructions, and product listing.
- B. Unless otherwise indicated and where not otherwise restricted, use conduit types indicated for specified applications. Where more than one listed application applies, comply with most restrictive requirements. Where conduit type for particular application is not specified, use galvanized steel rigid metal conduit.
- C. Underground:
  - 1. Under Slab on Grade: Use galvanized steel rigid metal conduit or rigid PVC conduit.
  - 2. Exterior, Direct-Buried: Use galvanized steel rigid metal conduit or rigid PVC conduit.
  - 3. Exterior, Embedded Within Concrete: Use galvanized steel rigid metal conduit or rigid PVC conduit.
  - 4. Where rigid polyvinyl chloride (PVC) conduit is provided, transition to galvanized steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), or schedule 80 rigid PVC conduit where emerging from underground.
  - 5. Where rigid polyvinyl (PVC) conduit larger than 2-inch (53 mm) trade size is provided, use galvanized steel rigid metal conduit (RMC) elbows, galvanized steel intermediate metal conduit (IMC) elbows, stainless steel intermediate metal conduit (IMC) elbows, PVC-coated galvanized steel rigid metal conduit (RMC) elbows, or concrete-encased PVC elbows for bends.
  - 6. Where galvanized steel rigid metal conduit (RMC) or galvanized steel intermediate metal conduit (IMC) is installed in direct contact with earth where soil has resistivity of less than 2000 ohm-centimeters or is characterized as severely corrosive based on soils report or local experience, use corrosion protection tape, factory-applied corrosion protection coating, or field-applied corrosion protection compound acceptable to authorities having jurisdiction to provide supplementary corrosion protection.
  - 7. Where galvanized steel electrical metallic tubing (EMT) is installed in direct contact with earth, use corrosion protection tape, factory-applied corrosion protection coating, or field-applied corrosion protection compound acceptable to authorities having jurisdiction to provide supplementary corrosion protection.
  - 8. Where aluminum rigid metal conduit (RMC) or aluminum electrical metallic tubing (EMT) is installed in direct contact with earth, use corrosion protection tape, factory-applied corrosion protection coating, or field-applied corrosion protection compound acceptable to authorities having jurisdiction to provide supplementary corrosion protection.

9. Where galvanized rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), or galvanized steel electrical metallic tubing (EMT) emerges from concrete into soil, use corrosion protection tape, factory-applied corrosion protection coating, or field-applied corrosion protection compound acceptable to authorities having jurisdiction to provide supplementary corrosion protection for minimum of 4 inches on either side of where conduit emerges.
- D. Embedded Within Concrete:
  1. Within Slab on Grade (within structural slabs only where approved by Structural Engineer): Use galvanized steel rigid metal conduit or rigid PVC conduit.
  2. Within Slab Above Ground (within structural slabs only where approved by Structural Engineer): Use PVC-coated galvanized steel rigid metal conduit or rigid PVC conduit.
- E. Concealed Within Masonry Walls: Use intermediate metal conduit (IMC) or electrical metallic tubing (EMT).
- F. Concealed Within Hollow Stud Walls: Use intermediate metal conduit (IMC) or electrical metallic tubing (EMT).
- G. Concealed Above Accessible Ceilings: Use intermediate metal conduit (IMC) or electrical metallic tubing (EMT).
- H. Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), or galvanized steel electrical metallic tubing (EMT).
- I. Exposed, Interior, Not Subject to Physical Damage: Use galvanized steel rigid metal conduit, aluminum rigid metal conduit, or electrical metallic tubing (EMT).
- J. Exposed, Interior, Subject to Physical Damage: Use stainless steel rigid metal conduit (RMC), aluminum rigid metal conduit (RMC), stainless steel intermediate metal conduit (IMC), stainless steel electrical metallic tubing (EMT), or schedule 80 rigid PVC conduit.
- K. Exposed, Interior, Subject to Severe Physical Damage: Use stainless steel rigid metal conduit (RMC), aluminum rigid metal conduit (RMC), or stainless steel intermediate metal conduit (IMC).
- L. Exposed, Exterior: Use PVC-coated galvanized steel rigid metal conduit or aluminum rigid metal conduit.
- M. Exposed, Exterior, Subject to Severe Physical Damage: Use stainless steel rigid metal conduit (RMC) or stainless steel intermediate metal conduit (IMC).
- N. Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use intermediate metal conduit (IMC).
- O. Flexible Connections to Luminaires Above Accessible Ceilings: Use flexible metal conduit (FMC).
  1. Maximum Length: 6 feet.
- P. Flexible Connections to Vibrating Equipment:
  1. Dry Locations: Use flexible metal conduit (FMC).
  2. Damp, Wet, or Corrosive Locations: Use liquidtight flexible metal conduit (LFMC).
  3. Vibrating equipment includes, but is not limited to:
    - a. Transformers.
    - b. Motors.
- Q. Fished in Existing Walls, Where Necessary: Use flexible metal conduit (FMC) or galvanized steel electrical metallic tubing (EMT).

## **2.02 CONDUIT - GENERAL REQUIREMENTS**

- A. Comply with NFPA 70.
- B. Existing Work: Where existing conduits are indicated to be reused, they may be reused only where they comply with specified requirements, are free from corrosion, and integrity is verified by pulling mandrel through them.
- C. Provide conduit, fittings, supports, and accessories required for complete raceway system.

- D. Provide products listed, classified, and labeled as suitable for purpose intended.
- E. Minimum Conduit Size, Unless Otherwise Indicated:
  - 1. Branch Circuits: 3/4 inch (21 mm) trade size.
  - 2. Flexible Connections to Luminaires: 3/8-inch trade size.
  - 3. Underground, Interior: 1 inch (27 mm) trade size.
  - 4. Underground, Exterior: 1-inch trade size.
- F. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

### **2.03 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)**

- A. Manufacturers:
  - 1. Allied Tube & Conduit: [www.alliedeg.com](http://www.alliedeg.com)
  - 2. Republic Conduit: [www.republic-conduit.com](http://www.republic-conduit.com)
  - 3. Wheatland Tube, a Division of Zekelman Industries: [www.wheatland.com](http://www.wheatland.com)
- B. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.
- C. Fittings:
  - 1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 6.
  - 2. Material: Use steel or malleable iron.
  - 3. Connectors and Couplings: Use threaded type fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.

### **2.04 ALUMINUM RIGID METAL CONDUIT (RMC)**

- A. Manufacturers:
  - 1. Allied Tube & Conduit, a division of Atkore International: [www.alliedeg.com/#sle](http://www.alliedeg.com/#sle).
  - 2. Western Tube, a division of Zekelman Industries: [www.westerntube.com/#sle](http://www.westerntube.com/#sle).
  - 3. Wheatland Tube, a division of Zekelman Industries: [www.wheatland.com/#sle](http://www.wheatland.com/#sle).
- B. Description: NFPA 70, Type RMC aluminum rigid metal conduit complying with ANSI C80.5 and listed and labeled as complying with UL 6A.
- C. Fittings:
  - 1. Manufacturers:
    - a. ABB; T&B: [www.electrification.us.abb.com/#sle](http://www.electrification.us.abb.com/#sle).
    - b. Allied Tube & Conduit, a division of Atkore International: [www.alliedeg.us/#sle](http://www.alliedeg.us/#sle).
    - c. Bridgeport Fittings, LLC: [www.bptfittings.com/#sle](http://www.bptfittings.com/#sle).
    - d. Emerson Electric Co; O-Z/Gedney: [www.emerson.com/#sle](http://www.emerson.com/#sle).
  - 2. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 6A.
  - 3. Material: Use aluminum.
  - 4. Connectors and Couplings: Use threaded type fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.

### **2.05 FLEXIBLE METAL CONDUIT (FMC)**

- A. Manufacturers:
  - 1. AFC Cable Systems, Inc: [www.afcweb.com](http://www.afcweb.com)
  - 2. Electri-Flex Company: [www.electriflex.com](http://www.electriflex.com)
  - 3. International Metal Hose: [www.metalhose.com](http://www.metalhose.com)
- B. Description: NFPA 70, Type FMC standard-wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems.
- C. Fittings:
  - 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  - 2. Material: Use steel or malleable iron.



## **2.06 GALVANIZED STEEL ELECTRICAL METALLIC TUBING (EMT)**

- A. Manufacturers:
  - 1. Allied Tube & Conduit: [www.alliedeg.com](http://www.alliedeg.com)
  - 2. Republic Conduit: [www.republic-conduit.com](http://www.republic-conduit.com)
  - 3. Wheatland Tube, a Division of Zekelman Industries: [www.wheatland.com](http://www.wheatland.com)
- B. Description: NFPA 70, Type EMT galvanized steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.
- C. Fittings:
  - 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  - 2. Material: Use steel or malleable iron.
  - 3. Connectors and Couplings: Use compression/gland or set-screw type.
    - a. Do not use indenter type connectors and couplings.
  - 4. Damp or Wet Locations, Where Permitted: Use fittings listed for use in wet locations.
  - 5. Embedded Within Concrete, Where Permitted: Use fittings listed as concrete-tight. Fittings that require taping to be concrete-tight are acceptable.

## **2.07 ALUMINUM ELECTRICAL METALLIC TUBING (EMT)**

- A. Description: NFPA 70, Type EMT aluminum electrical metallic tubing listed and labeled as complying with UL 797A.
- B. Fittings:
  - 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B; listed for use with aluminum EMT.
  - 2. Material: Use aluminum.
  - 3. Connectors and Couplings: Use compression/gland or set-screw type.
    - a. Do not use indenter type connectors and couplings.

## **2.08 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT**

- A. Manufacturers:
  - 1. ABB; Carlon: [www.carlon.com/#sle](http://www.carlon.com/#sle).
  - 2. Cantex Inc: [www.cantexinc.com](http://www.cantexinc.com)
  - 3. JM Eagle: [www.jmeagle.com](http://www.jmeagle.com)
- B. Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage; rated for use with conductors rated 90 degrees C.
- C. Fittings:
  - 1. Manufacturer: Same as manufacturer of conduit to be connected.
  - 2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

## **2.09 ACCESSORIES**

- A. Corrosion Protection Tape: PVC-based, minimum thickness of 20 mil, 0.020 inch.
- B. Conduit Joint Compound: Corrosion-resistant, electrically conductive compound listed as complying with UL 2419; suitable for use with conduit to be installed.
- C. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- D. Pull Strings: Use nylon or polyester tape with average breaking strength of not less than 1,250 lbf.
- E. Foam Conduit Sealant:
  - 1. Removable, two-part, closed-cell foam, specifically designed for sealing conduit openings against water, moisture, gases, and dust.

2. Suitable for use with conductors/cables and associated insulation/jackets to be installed.
  3. Rated to hold minimum of 10 ft water head pressure.
- F. Conduit Mechanical Seals:
1. Listed as complying with UL 514B.
  2. Specifically designed for sealing conduit openings against water, moisture, gases, and dust.
  3. Suitable for sealing around conductors/cables to be installed.
- G. Sealing Compound for Hazardous/Classified Location Sealing Fittings: Listed for use with particular fittings to be installed.
- H. Sealing Systems for Concrete Penetrations:
1. Sleeves: Provide water stop ring or cement coating that bonds to concrete to prevent water infiltration.
  2. Rate for minimum of 40 psig; suitable for sealing around conduits to be installed.
- I. Sealing Systems for Roof Penetrations: Premanufactured components and accessories as required to preserve integrity of roofing system and maintain roof warranty; suitable for conduits and roofing system to be installed; designed to accommodate existing penetrations where applicable.
- J. Firestop Sleeves: Listed; provide as required to preserve fire resistance rating of building elements.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive conduits.
- C. Verify that conditions are satisfactory for installation prior to starting work.

#### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install conduit in accordance with NECA 1.
- C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.
- D. Install aluminum rigid metal conduit (RMC) in accordance with NECA 102.
- E. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.
- F. Conduit Routing:
  1. Unless dimensioned, conduit routing indicated is diagrammatic.
  2. When conduit destination is indicated without specific routing, determine exact routing required.
  3. Conceal conduits unless specifically indicated to be exposed.
  4. Conduits in the following areas may be exposed, unless otherwise indicated:
    - a. Electrical rooms.
    - b. Mechanical equipment rooms.
  5. Unless otherwise approved, do not route exposed conduits:
    - a. Across floors.
    - b. Across roofs.
    - c. Across top of parapet walls.
    - d. Across building exterior surfaces.
  6. Conduits installed underground or embedded in concrete may be routed in shortest possible manner unless otherwise indicated. Route other conduits parallel or perpendicular to building structure and surfaces, following surface contours where practical.
  7. Arrange conduit to maintain adequate headroom, clearances, and access.

8. Arrange conduit to provide no more than equivalent of four 90-degree bends between pull points.
  9. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
  10. Group parallel conduits in same area on common rack.
- G. Conduit Support:
1. Secure and support conduits in accordance with NFPA 70 using suitable supports and methods approved by authorities having jurisdiction; see Section 26 0529.
  2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
  3. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
  4. Use conduit strap to support single surface-mounted conduit.
    - a. Use clamp back spacer with conduit strap for damp and wet locations to provide space between conduit and mounting surface.
  5. Use metal channel/strut with accessory conduit clamps to support multiple parallel surface-mounted conduits.
  6. Use trapeze hangers assembled from threaded rods and metal channel/strut with accessory conduit clamps to support multiple parallel suspended conduits.
  7. Use of wire for support of conduits is not permitted.
- H. Connections and Terminations:
1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
  2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
  3. Use suitable adapters where required to transition from one type of conduit to another.
  4. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
  5. Provide insulating bushings, insulated throats, or listed metal fittings with smooth, rounded edges at conduit terminations to protect conductors.
  6. Secure joints and connections to provide mechanical strength and electrical continuity.
- I. Penetrations:
1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
  2. Make penetrations perpendicular to surfaces unless otherwise indicated.
  3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
  4. Conceal bends for conduit risers emerging above ground.
  5. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
  6. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty.
  7. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Division 07.
- J. Underground Installation:
1. Provide trenching and backfilling in accordance with Division 31.
- K. Concrete Encasement: Where conduits not otherwise embedded within concrete are indicated to be concrete-encased, provide concrete in accordance with Division 03 with minimum concrete cover of 2 inches on all sides unless otherwise indicated.

- L. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
  - 1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
  - 2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.
  - 3. Where conduits are subject to earth movement by settlement or frost.
- M. Conduit Sealing:
  - 1. Use foam conduit sealant to prevent entry of moisture and gases. This includes, but is not limited to:
    - a. Where conduits enter building from outside.
    - b. Where service conduits enter building from underground distribution system.
    - c. Where conduits enter building from underground.
    - d. Where conduits may transport moisture to contact live parts.
  - 2. Where conduits cross barriers between areas of potential substantial temperature differential, use foam conduit sealant at accessible point near penetration to prevent condensation. This includes, but is not limited to:
    - a. Where conduits pass from outdoors into conditioned interior spaces.
    - b. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.
- N. Provide grounding and bonding; see Section 26 0526.
- O. Identify conduits; see Section 26 0553.

### **3.03 PROTECTION**

- A. Immediately after installation of conduit, use suitable manufactured plugs to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

**END OF SECTION**

**SECTION 26 0533.16**  
**BOXES FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.
- B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements.
- B. Division 03 - Concrete: Concrete.
- C. Division 07 - Thermal and Moisture Protection: Firestopping.
- D. Division 08 - Openings: Access Doors.
- E. Section 08 3100 - Access Doors and Panels: Panels for maintaining access to concealed boxes.
- F. Section 26 0005 - Basic Electrical Requirements.
- G. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- H. Section 26 0529 - Hangers and Supports for Electrical Systems.
- I. Section 26 0533.13 - Conduit for Electrical Systems:
  - 1. Conduit bodies and other fittings.
  - 2. Additional requirements for locating boxes to limit conduit length and/or number of bends between pulling points.
- J. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- K. Section 26 2726 - Wiring Devices:
  - 1. Wall plates.
- L. Section 26 2813 - Fuses: Spare fuse cabinets.

**1.03 REFERENCE STANDARDS**

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- B. NECA 130 - Standard for Installing and Maintaining Wiring Devices; 2016.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2020.
- D. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2014.
- E. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports; 2013 (Reaffirmed 2020).
- F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. SCTE 77 - Specifications for Underground Enclosure Integrity; 2017.
- H. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.
- I. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.
- J. UL 508A - Industrial Control Panels; Current Edition, Including All Revisions.
- K. UL 514A - Metallic Outlet Boxes; Current Edition, Including All Revisions.

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:

1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
6. Coordinate the work with other trades to preserve insulation integrity.
7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
8. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

### **1.05 SUBMITTALS**

- A. Contractor shall provide submittals for equipment listed herein. Refer to Division 01 for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for cabinets and enclosures, boxes for hazardous (classified) locations, floor boxes, and underground boxes/enclosures.
  1. Underground Boxes/Enclosures: Include reports for load testing in accordance with SCTE 77 certified by a professional engineer or an independent testing agency upon request.
- C. Project Record Documents: Record actual locations for outlet and device boxes, pull boxes, cabinets and enclosures, floor boxes, and underground boxes/enclosures.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  1. See Section 01 6000 - Product Requirements, for additional provisions.
  2. Keys for Lockable Enclosures: Two of each different key.

## **PART 2 PRODUCTS**

### **2.01 BOXES**

- A. General Requirements:
  1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
  2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
  3. Provide products listed, classified, and labeled as suitable for the purpose intended.
  4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
  5. Provide grounding terminals within boxes where equipment grounding conductors terminate.
- B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
  1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
  2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
  3. Use suitable concrete type boxes where flush-mounted in concrete.
  4. Use suitable masonry type boxes where flush-mounted in masonry walls.
  5. Use raised covers suitable for the type of wall construction and device configuration where required.
  6. Use shallow boxes where required by the type of wall construction.
  7. Do not use "through-wall" boxes designed for access from both sides of wall.

8. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
9. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
10. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
11. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.
12. Wall Plates: Comply with Section 26 2726.
13. Manufacturers:
  - a. Cooper Crouse-Hinds, a division of Eaton Corporation: [www.cooperindustries.com](http://www.cooperindustries.com)
  - b. Hubbell Incorporated; Bell Products: [www.hubbell-rtb.com](http://www.hubbell-rtb.com)
  - c. Hubbell Incorporated; RACO Products: [www.hubbell-rtb.com](http://www.hubbell-rtb.com)
  - d. O-Z/Gedney, a brand of Emerson Electric Co: [www.emerson.com](http://www.emerson.com)
  - e. Thomas & Betts Corporation: [www.tnb.com](http://www.tnb.com)
- C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
  1. Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
  2. NEMA 250 Environment Type, Unless Otherwise Indicated:
  3. Junction and Pull Boxes Larger Than 100 cubic inches:
    - a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
    - b. Boxes 6 square feet and Larger: Provide sectionalized screw-cover or hinged-cover enclosures.
  4. Cabinets and Hinged-Cover Enclosures, Other Than Junction and Pull Boxes:
    - a. Provide lockable hinged covers, all locks keyed alike unless otherwise indicated.
    - b. Back Panels: Painted steel, removable.
    - c. Terminal Blocks: Provide voltage/current ratings and terminal quantity suitable for purpose indicated, with 25 percent spare terminal capacity.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive boxes.
- C. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide separate boxes for emergency power and normal power systems.
- E. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.
- F. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.
- G. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.
- H. Box Locations:
  1. Locate boxes to be accessible. Provide access panels in accordance with Division 08 as required where approved by the Architect.
  2. Unless dimensioned, box locations indicated are approximate.

3. Locate boxes as required for devices installed under other sections or by others.
  4. Locate boxes so that wall plates do not span different building finishes.
  5. Locate boxes so that wall plates do not cross masonry joints.
  6. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.
  7. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.
    - a. Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches separation where wall is constructed with individual noncommunicating stud cavities or protect both boxes with listed putty pads.
  8. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 26 0533.13.
- I. Box Supports:
1. Secure and support boxes in accordance with NFPA 70 and Section 26 0529 using suitable supports and methods approved by the authority having jurisdiction.
  2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.
- J. Install boxes plumb and level.
- K. Flush-Mounted Boxes:
1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
  2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
  3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.
- L. Install boxes as required to preserve insulation integrity.
- M. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- N. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.
- O. Close unused box openings.
- P. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.
- Q. Provide grounding and bonding in accordance with Section 26 0526.

### **3.03 PROTECTION**

- A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

**END OF SECTION**



**SECTION 26 0533.23**  
**SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Surface raceway systems.
- B. Wireways.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements.
- B. Division 02 - Existing Conditions: Demolition, cleaning and disposal requirements.
- C. Section 26 0005 - Basic Electrical Requirements.
- D. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- E. Section 26 0529 - Hangers and Supports for Electrical Systems.
- F. Section 26 0533.13 - Conduit for Electrical Systems.
- G. Section 26 0533.16 - Boxes for Electrical Systems.
- H. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- I. Section 26 2726 - Wiring Devices: Receptacles.

**1.03 REFERENCE STANDARDS**

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- B. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2020.
- D. NEMA PRP 5 - Installation Guidelines for Surface Nonmetallic Raceway; 2021.
- E. UL 870 - Wireways, Auxiliary Gutters, and Associated Fittings; Current Edition, Including All Revisions.

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the placement of raceways with millwork, furniture, equipment, etc. installed under other sections or by others.
  - 2. Coordinate rough-in locations of outlet boxes provided under Section 26 0533.16 and conduit provided under Section 26 0533.13 as required for installation of raceways provided under this section.
  - 3. Verify minimum sizes of raceways with the actual conductors and components to be installed.
  - 4. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not install raceways until final surface finishes and painting are complete.
  - 2. Do not begin installation of conductors and cables until installation of raceways is complete between outlet, junction and splicing points.

**1.05 SUBMITTALS**

- A. Contractor shall provide submittals for equipment listed herein. Refer to Division 01 for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets including dimensions, knockout sizes and locations, materials, fabrication details, finishes, service condition requirements, and accessories.

1. Surface Raceway Systems: Include information on fill capacities for conductors and cables.

## **PART 2 PRODUCTS**

### **2.01 RACEWAY REQUIREMENTS**

- A. Provide all components, fittings, supports, and accessories required for a complete raceway system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Do not use raceways for applications other than as permitted by NFPA 70 and product listing.

### **2.02 SURFACE RACEWAY SYSTEMS**

- A. Manufacturers:
  1. Hubbell Incorporated: [www.hubbell.com](http://www.hubbell.com)
  2. Legrand North America, Inc: [www.legrand.us/#sle](http://www.legrand.us/#sle).
  3. MonoSystems, Inc: [www.monosystems.com](http://www.monosystems.com)
  4. Wiremold, a brand of Legrand North America, Inc: [www.legrand.us](http://www.legrand.us)

### **2.03 WIREWAYS**

- A. Manufacturers:
  1. Cooper B-Line, a division of Cooper Industries: [www.cooperindustries.com](http://www.cooperindustries.com)
  2. Enduro Composites: [www.endurocomposites.com](http://www.endurocomposites.com)
  3. Hoffman, a brand of Pentair Technical Products: [www.hoffmanonline.com](http://www.hoffmanonline.com)
  4. Schneider Electric; Square D Products: [www.schneider-electric.us](http://www.schneider-electric.us)
- B. Description: Lay-in wireways and wiring troughs with removable covers; listed and labeled as complying with UL 870.
- C. Wireway Type, Unless Otherwise Indicated:
  1. Indoor Clean, Dry Locations: NEMA 250, Type 1, painted steel with screw-cover.
  2. Outdoor Locations: NEMA 250, Type 3R, painted steel with screw-cover; include provision for padlocking.
- D. Finish for Painted Steel Wireways: Manufacturer's standard grey unless otherwise indicated.
- E. Where wireway size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes and conduit terminations are installed in proper locations and are properly sized in accordance with NFPA 70 to accommodate raceways.
- C. Verify that mounting surfaces are ready to receive raceways and that final surface finishes are complete, including painting.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Surface Nonmetallic Raceways: Install in accordance with NEMA PRP 5.
- D. Install raceways plumb and level.
- E. Arrange wireways and associated raceway connections to comply with NFPA 70, including but not limited to requirements for deflected conductors and wireways used as pullboxes. Increase size of wireway where necessary.
- F. Secure and support raceways in accordance with Section 26 0529 at intervals complying with NFPA 70 and manufacturer's requirements.

- G. Close unused raceway openings.
- H. Provide grounding and bonding in accordance with Section 26 0526.

**END OF SECTION**

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**SECTION 26 0553**  
**IDENTIFICATION FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Electrical identification requirements.
- B. Identification nameplates and labels.
- C. Wire and cable markers.
- D. Voltage markers.
- E. Underground warning tape.
- F. Floor marking tape.
- G. Warning signs and labels.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements.
- B. Division 09 - Finishes: Interior and Exterior Painting.
- C. Section 26 0005 - Basic Electrical Requirements
- D. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables: Color coding for power conductors and cables 600 V and less; vinyl color coding electrical tape.
- E. Section 26 0536 - Cable Trays for Electrical Systems: Additional identification requirements for cable tray systems.
- F. Section 26 0573 - Power System Studies: Arc flash hazard warning labels.
- G. Section 26 2726 - Wiring Devices: Device and wallplate finishes; factory pre-marked wallplates.

**1.03 REFERENCE STANDARDS**

- A. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- B. UL 969 - Marking and Labeling Systems; Current Edition, Including All Revisions.

**1.04 FIELD CONDITIONS**

- A. Do not install adhesive products when ambient temperature is lower than recommended by manufacturer.

**PART 2 PRODUCTS**

**2.01 IDENTIFICATION REQUIREMENTS**

- A. Existing Work: Unless specifically excluded, identify existing elements to remain that are not already identified in accordance with specified requirements.
- B. Identification for Equipment:
  - 1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
    - a. Panelboards:
      - 1) Identify ampere rating.
      - 2) Identify voltage and phase.
      - 3) Identify power source and circuit number. Include location when not within sight of equipment.
      - 4) Use typewritten circuit directory to identify load(s) served for panelboards with a door. Identify spares and spaces using pencil.
      - 5) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device. Do not identify spares and spaces.
    - b. Transformers:

- 1) Identify kVA rating.
- 2) Identify voltage and phase for primary and secondary.
- 3) Identify power source and circuit number. Include location when not within sight of equipment.
- c. Enclosed switches, circuit breakers, and motor controllers:
  - 1) Identify voltage and phase.
  - 2) Identify power source and circuit number. Include location when not within sight of equipment.
  - 3) Identify load(s) served. Include location when not within sight of equipment.
- d. Transfer Switches:
  - 1) Identify voltage and phase.
  - 2) Identify short circuit current rating based on the specific overcurrent protective device type and settings protecting the transfer switch.
2. Service Equipment:
  - a. Use identification nameplate to identify each service disconnecting means.
3. Emergency System Equipment:
  - a. Use identification nameplate or voltage marker to identify emergency system equipment in accordance with NFPA 70.
  - b. Use identification nameplate at each piece of service equipment to identify type and location of on-site emergency power sources.
4. Use identification nameplate to identify disconnect location for equipment with remote disconnecting means.
5. Use identification label or handwritten text using indelible marker on inside of door at each fused switch to identify required NEMA fuse class and size.
6. Use field-painted floor markings, floor marking tape, or warning labels to identify required equipment working clearances where indicated or where required by the authority having jurisdiction.
  - a. Field-Painted Floor Markings: Alternating black and white stripes, 3 inches wide, painted in accordance with Section 09 9123 and 09 9113.
7. Available Fault Current Documentation: Use identification label to identify the available fault current and date calculations were performed at locations requiring documentation by NFPA 70 including but not limited to the following.
  - a. Service equipment.
  - b. Industrial control panels.
  - c. Motor control centers.
  - d. Elevator control panels.
  - e. Industrial machinery.
- C. Identification for Conductors and Cables:
  1. Color Coding for Power Conductors 600 V and Less: Comply with Section 26 0519.
  2. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.
- D. Identification for Raceways:
  1. Use voltage markers to identify highest voltage present for accessible conduits at maximum intervals of 20 feet.
  2. Use voltage markers, color-coded bands, or factory-painted conduits to identify systems other than normal power system for accessible conduits.
    - a. Maximum Intervals: 20 feet.
    - b. Color-Coded Bands: Use field-painting or vinyl color coding electrical tape to mark bands 3 inches wide.
      - 1) Field-Painting: Comply with Section 09 9123 and 09 9113.
      - 2) Vinyl Color Coding Electrical Tape: Comply with Section 26 0519.
    - c. Color Code:

3. Use identification labels, handwritten text using indelible marker, or plastic marker tags to identify spare conduits at each end. Identify purpose and termination location.
  4. Use underground warning tape to identify underground raceways.
  5. Use voltage markers to identify highest voltage present for wireways at maximum intervals of 20 feet.
- E. Identification for Cable Tray: Comply with Section 26 0536.
- F. Identification for Boxes:
1. Use voltage markers to identify highest voltage present.
  2. Use voltage markers or color coded boxes to identify systems other than normal power system.
    - a. Color-Coded Boxes: Field-painted in accordance with Division 09 per the same color code used for raceways.
- G. Identification for Devices:
1. Wiring Device and Wallplate Finishes: Comply with Section 26 2726.
  2. Use identification label to identify fire alarm system devices.
    - a. For devices concealed above suspended ceilings, provide additional identification on ceiling tile below device location.
  3. Use identification label to identify serving branch circuit for all receptacles.
    - a. For receptacles in public areas or in areas as directed by Architect, provide identification on inside surface of wallplate.
- H. Identification for Luminaires:
1. Use permanent red dot on luminaire frame to identify luminaires connected to emergency power system.

## 2.02 IDENTIFICATION NAMEPLATES AND LABELS

- A. Identification Nameplates:
1. Manufacturers:
    - a. Brimar Industries, Inc: [www.brimar.com/#sle](http://www.brimar.com/#sle).
    - b. Kolbi Pipe Marker Co: [www.kolbipipemarkers.com/#sle](http://www.kolbipipemarkers.com/#sle).
    - c. Seton Identification Products: [www.seton.com/#sle](http://www.seton.com/#sle).
  2. Materials:
    - a. Indoor Clean, Dry Locations: Use plastic nameplates.
    - b. Outdoor Locations: Use plastic, stainless steel, or aluminum nameplates suitable for exterior use.
  3. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch; engraved text.
  4. Stainless Steel Nameplates: Minimum thickness of 1/32 inch; engraved or laser-etched text.
  5. Aluminum Nameplates: Anodized; minimum thickness of 1/32 inch; engraved or laser-etched text.
  6. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.
- B. Identification Labels:
1. Manufacturers:
    - a. Brady Corporation: [www.bradyid.com/#sle](http://www.bradyid.com/#sle).
    - b. Brother International Corporation: [www.brother-usa.com/#sle](http://www.brother-usa.com/#sle).
    - c. Panduit Corp: [www.panduit.com/#sle](http://www.panduit.com/#sle).
  2. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
  3. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.
- C. Format for Caution and Warning Messages:
1. Minimum Size: 2 inches by 4 inches.

2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.
  3. Text: All capitalized unless otherwise indicated.
  4. Minimum Text Height: 1/2 inch.
  5. Color: Black text on yellow background unless otherwise indicated.
- D. Format for Receptacle Identification:
1. Minimum Size: 3/8 inch by 1.5 inches.
  2. Legend: Power source and circuit number or other designation indicated.
  3. Text: All capitalized unless otherwise indicated.
  4. Minimum Text Height: 3/16 inch.
  5. Color: Black text on clear background.
- E. Format for Fire Alarm Device Identification:
1. Minimum Size: 3/8 inch by 1.5 inches.
  2. Legend: Designation indicated and device zone or address.
  3. Text: All capitalized unless otherwise indicated.
  4. Minimum Text Height: 3/16 inch.
  5. Color: Red text on white background.

### **2.03 WIRE AND CABLE MARKERS**

- A. Markers for Conductors and Cables: Use wrap-around self-adhesive vinyl cloth, wrap-around self-adhesive vinyl self-laminating, heat-shrink sleeve, plastic sleeve, plastic clip-on, or vinyl split sleeve type markers suitable for the conductor or cable to be identified.
- B. Markers for Conductor and Cable Bundles: Use plastic marker tags secured by nylon cable ties.
- C. Legend: Power source and circuit number or other designation indicated.
- D. Text: Use factory pre-printed or machine-printed text, all capitalized unless otherwise indicated.
- E. Minimum Text Height: 1/8 inch.
- F. Color: Black text on white background unless otherwise indicated.

### **2.04 VOLTAGE MARKERS**

- A. Markers for Conduits: Use factory pre-printed self-adhesive vinyl, self-adhesive vinyl cloth, or vinyl snap-around type markers.
- B. Markers for Boxes and Equipment Enclosures: Use factory pre-printed self-adhesive vinyl or self-adhesive vinyl cloth type markers.
- C. Minimum Size:
  1. Markers for Conduits: As recommended by manufacturer for conduit size to be identified.
  2. Markers for Pull Boxes: 1 1/8 by 4 1/2 inches.
  3. Markers for Junction Boxes: 1/2 by 2 1/4 inches.
- D. Legend:
  1. Markers for Voltage Identification: Highest voltage present.
  2. Markers for System Identification:
    - a. Emergency Power System: Text "EMERGENCY".
- E. Color: Black text on orange background unless otherwise indicated.

### **2.05 UNDERGROUND WARNING TAPE**

- A. Materials: Use non-detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.
- B. Non-detectable Type Tape: 6 inches wide, with minimum thickness of 4 mil.
- C. Legend: Type of service, continuously repeated over full length of tape.
- D. Color:
  1. Tape for Buried Power Lines: Black text on red background.



2. Tape for Buried Communication, Alarm, and Signal Lines: Black text on orange background.

## **2.06 FLOOR MARKING TAPE**

- A. Floor Marking Tape for Equipment Working Clearance Identification: Self-adhesive vinyl or polyester tape with overlamine, 3 inches wide, with alternating black and white stripes.

## **2.07 WARNING SIGNS AND LABELS**

- A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.
- B. Warning Signs:
  1. Materials:
    - a. Indoor Dry, Clean Locations: Use factory pre-printed rigid plastic or self-adhesive vinyl signs.
    - b. Outdoor Locations: Use factory pre-printed rigid aluminum signs.
  2. Rigid Signs: Provide four mounting holes at corners for mechanical fasteners.
  3. Minimum Size: 7 by 10 inches unless otherwise indicated.
- C. Warning Labels:
  1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
  2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
  3. Minimum Size: 2 by 4 inches unless otherwise indicated.

## **PART 3 EXECUTION**

### **3.01 PREPARATION**

- A. Clean surfaces to receive adhesive products according to manufacturer's instructions.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
  1. Surface-Mounted Equipment: Enclosure front.
  2. Flush-Mounted Equipment: Inside of equipment door.
  3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
  4. Elevated Equipment: Legible from the floor or working platform.
  5. Branch Devices: Adjacent to device.
  6. Interior Components: Legible from the point of access.
  7. Conduits: Legible from the floor.
  8. Boxes: Outside face of cover.
  9. Conductors and Cables: Legible from the point of access.
  10. Devices: Outside face of cover.
- C. Install identification products centered, level, and parallel with lines of item being identified.
- D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws and to interior surfaces using self-adhesive backing or epoxy cement.
- E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.
- F. Install underground warning tape above buried lines with one tape per trench at 3 inches below finished grade.
- G. Secure rigid signs using stainless steel screws.
- H. Mark all handwritten text, where permitted, to be neat and legible.

### **END OF SECTION**

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**SECTION 26 2416  
PANELBOARDS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Power distribution panelboards.
- B. Lighting and appliance panelboards.
- C. Overcurrent protective devices for panelboards.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements.
- B. Division 02 - Existing Conditions: Demolition, cleaning and disposal requirements, cutting and patching requirements, and repairs.
- C. Division 03 - Concrete: Concrete equipment pads.
- D. Section 26 0005 - Basic Electrical Requirements.
- E. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- F. Section 26 0529 - Hangers and Supports for Electrical Systems.
- G. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- H. Section 26 0573 - Power System Studies: Additional criteria for the selection and adjustment of equipment and associated protective devices specified in this section.
- I. Section 26 2200 - Low-Voltage Transformers: Small power centers with integral primary breaker, transformer, and panelboard.
- J. Section 26 2813 - Fuses: Fuses for fusible switches and spare fuse cabinets.
- K. Section 26 4300 - Surge Protective Devices.

**1.03 REFERENCE STANDARDS**

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service; 2013e, with Amendments (2022).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- C. NECA 407 - Standard for Installing and Maintaining Panelboards; 2015.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2020.
- E. NEMA PB 1 - Panelboards; 2011.
- F. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 1000 Volts or Less; 2023.
- G. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems; 2021.
- H. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.
- J. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.
- K. UL 67 - Panelboards; Current Edition, Including All Revisions.
- L. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.
- M. UL 869A - Reference Standard for Service Equipment; Current Edition, Including All Revisions.
- N. UL 943 - Ground-Fault Circuit-Interrupters; Current Edition, Including All Revisions.

- O. UL 1699 - Arc-Fault Circuit-Interrupters; Current Edition, Including All Revisions.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
  2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
  4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
  5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

#### **1.05 SUBMITTALS**

- A. Contractor shall provide submittals for equipment listed herein. Refer to Division 01 for submittal procedures.
- B. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
1. Include documentation of listed series ratings as indicated in Section 26 0573.
- 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, and installation of product.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Panelboard Keys: Two of each different key.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. ABB/GE: [www.geindustrial.com](http://www.geindustrial.com)
- B. Eaton Corporation: [www.eaton.com](http://www.eaton.com)
- C. Schneider Electric; Square D Products: [www.schneider-electric.us](http://www.schneider-electric.us)
- D. Siemens Industry, Inc: [www.usa.siemens.com](http://www.usa.siemens.com)
- E. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

#### **2.02 PANELBOARDS - GENERAL REQUIREMENTS**

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
1. Altitude: Less than 6,600 feet.
  2. Ambient Temperature:
    - a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
    - b. Panelboards Containing Fusible Switches: Between -22 degrees F and 104 degrees F.
- C. Short Circuit Current Rating:
1. Provide panelboards with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.

- D. Panelboards Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- E. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.
- F. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.
- G. Bussing: Sized in accordance with UL 67 temperature rise requirements.
  - 1. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
- H. Conductor Terminations: Suitable for use with the conductors to be installed.
- I. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1.
    - b. Outdoor Locations: Type 3R.
  - 2. Boxes: Galvanized steel unless otherwise indicated.
    - a. Provide wiring gutters sized to accommodate the conductors to be installed.
    - b. Increase gutter space as required where sub-feed lugs, feed-through lugs, gutter taps, or oversized lugs are provided.
  - 3. Fronts:
    - a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
    - b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
  - 4. Lockable Doors: All locks keyed alike unless otherwise indicated.
- J. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- K. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 4300, list and label panelboards as a complete assembly including surge protective device.
  - 1. Provide Surge Protective Devices internally mounted within all panels which are specified as part of the Emergency distribution power system.
- L. Multi-Section Panelboards: Provide enclosures of the same height, with feed-through lugs or sub-feed lugs and feeders as indicated or as required to interconnect sections.
- M. Load centers are not acceptable.

### **2.03 POWER DISTRIBUTION PANELBOARDS**

- A. Description: Panelboards complying with NEMA PB 1, power and feeder distribution type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:
  - 1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
  - 2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
  - 1. Phase and Neutral Bus Material: Aluminum.
  - 2. Ground Bus Material: Aluminum.
- D. Circuit Breakers:
  - 1. Provide bolt-on type or plug-in type secured with locking mechanical restraints.
- E. Enclosures:
  - 1. Provide surface-mounted enclosures unless otherwise indicated.
  - 2. Fronts: Provide trims to cover access to load terminals, wiring gutters, and other live parts, with exposed access to overcurrent protective device handles.

3. Provide clear plastic circuit directory holder mounted on inside of door.

#### **2.04 LIGHTING AND APPLIANCE PANELBOARDS**

- A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:
  1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
  2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
  1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
  2. Phase and Neutral Bus Material: Aluminum.
  3. Ground Bus Material: Aluminum.
- D. Circuit Breakers: Thermal magnetic bolt-on type unless otherwise indicated.
- E. Enclosures:
  1. Provide surface-mounted or flush-mounted enclosures as indicated.
  2. Provide clear plastic circuit directory holder mounted on inside of door.

#### **2.05 OVERCURRENT PROTECTIVE DEVICES**

- A. Molded Case Circuit Breakers:
  1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
  2. Interrupting Capacity:
    - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated.
    - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
  3. Conductor Terminations:
    - a. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
  4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
  5. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
  6. Provide the following circuit breaker types where indicated:
    - a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
    - b. Ground Fault Equipment Protection Circuit Breakers: Designed to trip at 30 mA for protection of equipment.
    - c. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Combination type listed as complying with UL 1699.
    - d. 100 Percent Rated Circuit Breakers: Listed for application within the panelboard where installed at 100 percent of the continuous current rating.
  7. Do not use tandem circuit breakers.
  8. Do not use handle ties in lieu of multi-pole circuit breakers.
  9. Provide multi-pole circuit breakers for multi-wire branch circuits as required by NFPA 70.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.

- C. Verify that mounting surfaces are ready to receive panelboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- E. Provide required support and attachment in accordance with Section 26 0529.
- F. Install panelboards plumb.
- G. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- H. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.
- I. Provide minimum of six spare 1 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling and below floor.
- J. Provide grounding and bonding in accordance with Section 26 0526.
- K. Install all field-installed branch devices, components, and accessories.
- L. Provide filler plates to cover unused spaces in panelboards.
- M. Provide circuit breaker lock-on devices to prevent unauthorized personnel from de-energizing essential loads where indicated. Also provide for the following:
  - 1. Fire detection and alarm circuits.
  - 2. Intrusion detection and access control system circuits.
  - 3. Video surveillance system circuits.

### **3.03 FIELD QUALITY CONTROL**

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Fusible Switches: Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.
- C. Molded Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than 225 amperes. Tests listed as optional are not required.
- D. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
- E. Test GFCI circuit breakers to verify proper operation.
- F. Test AFCI circuit breakers to verify proper operation.
- G. Correct deficiencies and replace damaged or defective panelboards or associated components.

### **3.04 ADJUSTING**

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of panelboard fronts.
- C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

**END OF SECTION**

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**SECTION 26 2726  
WIRING DEVICES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Wall switches.
- B. Receptacles.
- C. Wall plates and covers.

**1.02 RELATED REQUIREMENTS**

- A. Division 01 - General Requirements: Project administrative and procedural requirements.
- B. Division 02 - Existing Conditions: Demolition, cleaning and disposal requirements, cutting and patching requirements, and repairs.
- C. Section 26 0005 - Basic Electrical Requirements.
- D. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables: Manufactured wiring systems for use with access floor boxes with compatible pre-wired connectors.
- E. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- F. Section 26 0533.16 - Boxes for Electrical Systems.
- G. Section 26 0533.23 - Surface Raceways for Electrical Systems: Surface raceway systems, including multioutlet assemblies.
- H. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- I. Section 26 0583 - Wiring Connections: Cords and plugs for equipment.
- J. Section 26 0935 - Distributed Digital Lighting Control System: Devices for automatic control of lighting, including occupancy sensors, in-wall switches and timers.

**1.03 REFERENCE STANDARDS**

- A. FS W-C-596 - Connector, Electrical, Power, General Specification for; 2014h, with Amendments (2017).
- B. FS W-S-896 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification); 2014g, with Amendment (2017).
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- D. NECA 130 - Standard for Installing and Maintaining Wiring Devices; 2016.
- E. NEMA WD 1 - General Color Requirements for Wiring Devices; 1999 (Reaffirmed 2020).
- F. NEMA WD 6 - Wiring Devices - Dimensional Specifications; 2021.
- G. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. UL 20 - General-Use Snap Switches; Current Edition, Including All Revisions.
- I. UL 498 - Attachment Plugs and Receptacles; Current Edition, Including All Revisions.
- J. UL 514D - Cover Plates for Flush-Mounted Wiring Devices; Current Edition, Including All Revisions.
- K. UL 943 - Ground-Fault Circuit-Interrupters; Current Edition, Including All Revisions.
- L. UL 1310 - Class 2 Power Units; Current Edition, Including All Revisions.

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.

2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
  3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.
  4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
  5. Coordinate the core drilling of holes for poke-through assemblies with the work covered under other sections.
  6. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.
- B. Sequencing:
1. Do not install wiring devices until final surface finishes and painting are complete.

### **1.05 SUBMITTALS**

- A. Contractor shall provide submittals for equipment listed herein. Refer to Division 01 for submittal procedures.

## **PART 2 PRODUCTS**

### **2.01 WIRING DEVICES - GENERAL REQUIREMENTS**

- A. Provide wiring devices suitable for intended use with ratings adequate for load served.

### **2.02 WIRING DEVICE APPLICATIONS**

- A. Provide wiring devices suitable for intended use and with ratings adequate for load served.
- B. For single receptacles installed on an individual branch circuit, provide receptacle with ampere rating not less than that of the branch circuit.
- C. Provide weather resistant GFCI receptacles with specified weatherproof covers for receptacles installed outdoors or in damp or wet locations.
- D. Provide tamper resistant receptacles for receptacles installed in areas listed below:
1. All 15 and 20-ampere 125 and 250-volt nonlocking type receptacles in the areas listed below shall be listed tamper-resistant receptacles, unless otherwise excluded in NEC.
    - a. Dwelling units in all areas specified in NEC 210.52 and 550.13.
    - b. All areas listed in NEC 406.12.
- E. Provide GFCI protection for receptacles installed within 6 feet of sinks.
- F. Provide GFCI protection for receptacles installed in kitchens.
- G. Provide GFCI protection for receptacles serving electric drinking fountains.
1. Outlet shall be readily accessible.
- H. Provide GFCI protection for outlets serving vending machines. Outlets shall be readily accessible.

### **2.03 WIRING DEVICE FINISHES**

- A. Provide wiring device finishes as described below unless otherwise indicated.
- B. Wiring Devices, Unless Otherwise Indicated: White with gray stainless steel wall plate.
- C. Wiring Devices Connected to Emergency Power: Red with stainless steel wall plate factory engraved "Emergency".

### **2.04 WALL SWITCHES**

- A. Wall Switches - General Requirements: AC only, quiet operating, general-use snap switches with silver alloy contacts, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 20 and where applicable, FS W-S-896; types as indicated on the drawings.
1. Wiring Provisions: Terminal screws for side wiring and screw actuated binding clamp for back wiring with separate ground terminal screw.

### **2.05 RECEPTACLES**

- A. Manufacturers:

1. Hubbell Incorporated: [www.hubbell.com](http://www.hubbell.com)
  2. Leviton Manufacturing Company, Inc: [www.leviton.com](http://www.leviton.com)
  3. Lutron Electronics Company, Inc; Designer Style: [www.lutron.com](http://www.lutron.com)
  4. Pass & Seymour, a brand of Legrand North America, Inc: [www.legrand.us](http://www.legrand.us)
- B. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498, and where applicable, FS W-C-596; types as indicated on the drawings.
1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
  2. NEMA configurations specified are according to NEMA WD 6.
- C. Convenience Receptacles:
1. Standard Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R; single or duplex as indicated on the drawings.
  2. Tamper Resistant Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type; single or duplex as indicated on the drawings.
  3. Tamper Resistant and Weather Resistant Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type and as weather resistant type complying with UL 498 Supplement SD suitable for installation in damp or wet locations; single or duplex as indicated on the drawings.
- D. GFCI Receptacles:
1. GFCI Receptacles - General Requirements: Self-testing, with feed-through protection and light to indicate ground fault tripped condition and loss of protection; listed as complying with UL 943, class A.
    - a. Provide test and reset buttons of same color as device.
  2. Standard GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style.
  3. Weather Resistant GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as weather resistant type complying with UL 498 Supplement SD suitable for installation in damp or wet locations.
  4. Tamper Resistant GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as tamper resistant type.
- E. USB Charging Devices:
1. USB Charging Devices - General Requirements: Listed as complying with UL 1310.
    - a. Charging Capacity - Two-Port Devices: 2.1 A, minimum.
  2. USB Charging/Tamper Resistant Receptacle Combination Devices: Two-port (Type A) USB charging device and receptacle, commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type; rectangular decorator style.
- F. USB Charging/GFCI Combination Devices:
1. Meets specifications indicated in this section for USB Charging Devices, GFCI Receptacles and Tamper-Resistant devices.
- G. Cable Reel Receptacles:
1. Reel shall have a heavy-duty spring motor, with self-contained rewind and non-sparking ratchet assembly, a 4-way roller and adjustable cable stop, and a safety chain. Reel shall lock when desired cable has been payed out, and unlock and retract when cable is pulled to release lock.
  2. Reel shall be provided with minimum 25 foot cable rated for 20 amperes with required phase conductors, neutral and equipment grounding conductor. Provide device with NEMA configuration as indicated in drawings.

## 2.06 WALL PLATES AND COVERS

- A. Manufacturers:
1. Hubbell Incorporated: [www.hubbell-wiring.com](http://www.hubbell-wiring.com)
  2. Leviton Manufacturing Company, Inc: [www.leviton.com](http://www.leviton.com)

3. Lutron Electronics Company, Inc: [www.lutron.com](http://www.lutron.com)
  4. Pass & Seymour, a brand of Legrand North America, Inc: [www.legrand.us](http://www.legrand.us)
  5. Source Limitations: Where wall controls are furnished as part of lighting control system, provide accessory matching receptacles and wallplates by the same manufacturer in locations indicated.
- B. Wall Plates: Comply with UL 514D.
1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
  2. Size: Standard.
  3. Screws: Metal with slotted heads finished to match wall plate finish.
- C. Stainless Steel Wall Plates: Brushed satin finish, Type 302 stainless steel.
- D. Weatherproof Receptacle Covers for Damp Locations: Gasketed, cast aluminum, with self-closing hinged cover and corrosion-resistant screws; listed as suitable for use in wet locations with cover closed.
- E. Weatherproof Receptacle Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- F. Verify that conditions are satisfactory for installation prior to starting work.

#### **3.02 PREPARATION**

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

#### **3.03 INSTALLATION**

- A. Perform work in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 26 0533.16 as required for installation of wiring devices provided under this section.
  1. Mounting Heights: Unless otherwise indicated, as follows:
    - a. Wall Switches: 48 inches above finished floor.
    - b. Receptacles: 18 inches above finished floor or 6 inches above counter.
  2. Where multiple receptacles, wall switches, or wall dimmers are installed at the same location and at the same mounting height, gang devices together under a common wall plate.
  3. Locate wall switches on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify Architect to obtain direction prior to proceeding with work.
- C. Install wiring devices in accordance with manufacturer's instructions.
- D. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

- E. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.
- F. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in pressure terminals that do not rely on screw-actuated binding.
- G. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- H. Provide GFCI receptacles with integral GFCI protection at each location indicated. Do not use feed-through wiring to protect downstream devices.
- I. Install wiring devices plumb and level with mounting yoke held rigidly in place.
- J. Install wall switches with OFF position down.
- K. Install vertically mounted receptacles with grounding pole on top and horizontally mounted receptacles with grounding pole on left.
- L. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- M. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.
- N. Identify wiring devices in accordance with Section 26 0553.

#### **3.04 FIELD QUALITY CONTROL**

- A. Inspect each wiring device for damage and defects.
- B. Operate each wall switch, wall dimmer, and fan speed controller with circuit energized to verify proper operation.
- C. Test each receptacle to verify operation and proper polarity.
- D. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.
- E. Correct wiring deficiencies and replace damaged or defective wiring devices.

**END OF SECTION**

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**SECTION 28 4200  
GAS DETECTION AND ALARM**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Gas detection and alarm systems and accessories.

**1.02 RELATED REQUIREMENTS**

- A. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- B. Section 26 0529 - Hangers and Supports for Electrical Systems.
- C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

**1.03 REFERENCED STANDARDS**

- A. ICC (IMC) - International Mechanical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- B. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code); 1989 (Corrigendum 2019).
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2020.
- E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. NFPA 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response; 2022.
- G. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances; Current Edition, Including All Revisions.

**1.04 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each system component. Include ratings, configurations, standard wiring diagrams, dimensions, service condition requirements, and installed features.
  - 1. Indicate gas(es) to be detected with associated detection unit sensitivity, range, accuracy, and response time.
  - 2. Indicate cable and tubing length limitations, if applicable.
- C. Shop Drawings: Include plan views indicating locations of system components and proposed size, type, and routing of conduits and/or cables.
  - 1. Indicate proposed arrangement of equipment; identify associated system components.
  - 2. Include wiring diagrams showing factory and field connections.
  - 3. Include requirements for interface with other systems.
  - 4. Include proposed sequence of operations.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.
- B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

**1.06 WARRANTY**

- A. See Section 01 7800 - Closeout Submittals for additional warranty requirements.
- B. Provide minimum 1 year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

- A. Critical Environment Technologies; represented by Bluefield Engineered Systems, LLC.
- B. American Gas Safety
- C. Substitutions: See Section 01 6000 - Product Requirements
- D. Source Limitations: Furnish gas detection systems produced by single manufacturer and obtained from single supplier.

## **2.02 GAS DETECTION CONTROLLER & SENSOR(S)**

- A. The device will be individually powered and capable of accepting the inputs of multiple devices. The unit will clearly display the condition of an alarm and provide hazardous or toxic gas levels via ppm or % of VOL. The device shall provide a re-set and test function.
  - 1. The device shall incorporate sensor technology to detect the below.
    - a. CH<sub>4</sub> (Methane)
    - b. CO (Carbon Monoxide)
- B. The unit shall be UL certified and listed. Mount the panel per manufacturer's instructions and recommendations.
- C. The device panel will be capable of transmitting alarm conditions to a BMS system through one or more dry contact relay outputs.
- D. The device panel will be capable of operating within relative humidity ranges of 5-95% non-condensing and temperature ranges of -4° F to 140° F (-20° C to 60° C).
- E. The device will be certified and listed to ANSI/UL 61010-1 3rd edition and CAN/CSA-C22.2 No. 61010-1.
- F. For local activation of audible alarms, the transmitter shall have an on-board device able to generate an audible output of 80 dBA @ 10 ft.
- G. The unit shall provide a traffic signal type colored TFT display, Green – all clear, Yellow – warning (low alarm) Red – Alarm.
- H. The sensors shall be UL listed to comply with UL2075 and incorporate filters to only look for the desired hazardous or toxic gases selected.
- I. Sensors shall be integral to unit or remote mounted as called for on plans.
- J. The remote mount sensor transmitters shall operate on power supplied by the control panel.
- K. Local Building Codes recommendations take precedence over these parameters. Coverage can differ depending on application.

## **2.03 ACCESSORIES**

- A. Detector Guards. The grid is made of a 9-gauge steel wire. The guard must be designed to allow calibration without removing the guards.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install hazardous / toxic gas monitoring equipment including sensors as shown on Contract Drawings, and as recommended by manufacturer of equipment, and as required by authorities having jurisdiction.
- B. Install conduit and wiring from device, gas valve, contactor and remote panic buttons as recommended by manufacturer of equipment.

### **3.02 FIELD QUALITY CONTROL**

- A. See Section 01 4000 - Quality Requirements for additional requirements.
- B. Provide services of manufacturer's authorized representative to prepare and start systems and support inspection and testing. Include manufacturer's reports with submittals.
- C. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.



- D. Provide equipment, tools, supplies, and personnel required to accomplish inspection and testing.
- E. Test to verify wiring is free of shorts and grounds.
- F. Prepare and start system in accordance with manufacturer's instructions.
- G. Program system parameters according to project requirements.
- H. Calibrate system in accordance with manufacturer's instructions, where applicable.
- I. Test system for proper operation.
- J. Test for proper interface with other systems.
- K. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.
- L. Submit detailed reports indicating inspection and testing results and corrective actions taken.

### **3.03 CLOSEOUT ACTIVITIES**

- A. Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.
- B. Training: Train Owner's personnel on operation, adjustment, and maintenance of system and associated components.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of two hours of training.
  - 3. Instructor: Manufacturer's authorized representative.
  - 4. Location: At project site.

**END OF SECTION**